2. ALTERNATIVE DESCRIPTIONS

As noted previously, a number of treatment alternatives were identified for the buried TRU and non-TRU waste. Of the alternatives identified, three TRU alternatives and two non-TRU alternatives were selected for future study. Feasibility level designs were generated for the five selected alternatives.

The TRU alternatives that were carried forward were:

- Alternative 1, Compact All
- Alternative 2b, Melt All
- Alternative 4a, Thermal Desorption, Chemical Leach and Incineration

The alternatives for treating the non-TRU material contaminated with VOCs that were carried forward were:

- Alternative 2aP, Incineration
- Alternative 3aP, Thermal Desorption.

The TRU and non-TRU alternatives were then combined to determine the overall facility designs, costs. and schedules.

The facility designs have been developed at a feasibility level at this stage, showing the major equipment items. These major equipment items are specifically identified in the cost estimates but many of the facility costs have been generated on a "per square foot" basis. As the final alternatives are selected, additional detail will be generated. The final designs will include all the safety and contamination control systems required by the DOE Orders as implemented in the DOE-ID Architectural Engineering Standards.

2.1 Alternative 1 (Compact All)

Alternative 1 (Compact All) uses no chemical or thermal treatment to change the form of the waste and focuses only on the minimum processing required to meet the WIPP WAC. Material (commingled waste and soil) is received from the retrieval facility and segregated into waste and soil fractions for assay. Once assayed the soil and waste is designated as either TRU or non-TRU. The TRU fraction is compacted where possible to reduce the volume of the material shipped to WIPP, thereby reducing the overall certification, transportation, and disposal costs. If the non-TRU portion is contaminated with PCBs or uranium above the action levels, it is placed in long-term storage. If it is contaminated with VOCs above the action level, it is treated by thermal desorption (Alternative 3aP) or incineration (Alternative 2aP) to remove VOCs. The non-contaminated non-TRU material and the treated non-TRU material are stabilized to meet the structural requirements and are returned to the pit. Figure 6 shows a simplified version of the process flow for Alternative 1. Detailed process flow diagrams and facility arrangements for this alternative are provided in Appendix I. Descriptions of the process and these facilities are provided below.

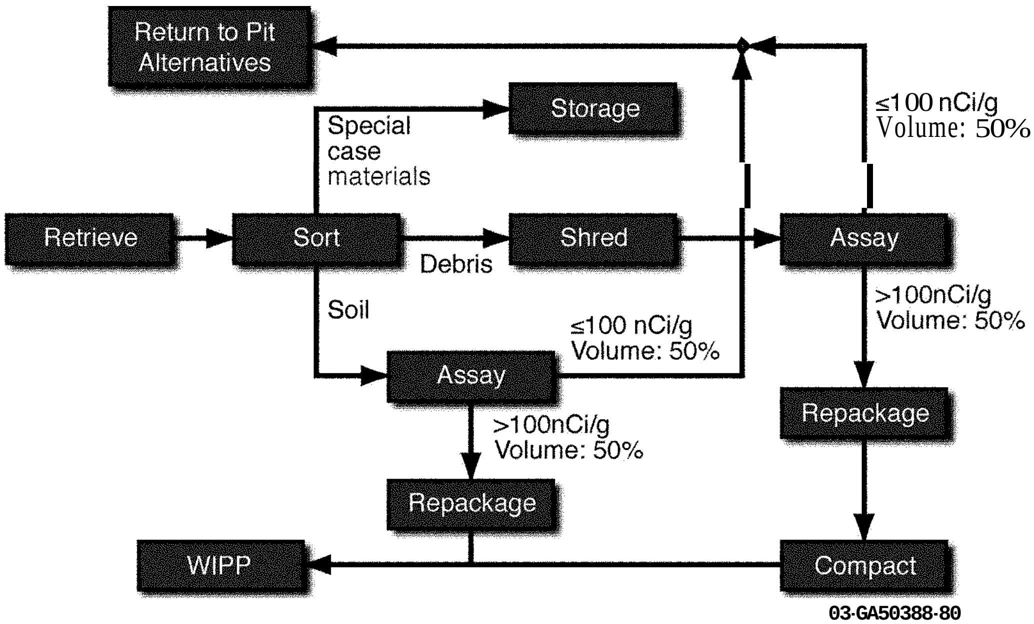

Figure 6. Alternative 1 (Compact All) process flow for treatment of the TRU material.

This alternative serves as the baseline for comparison to determine cost-effectiveness of more sophisticated treatment. There are three facilities (in addition to the Retrieval Facility) associated with this alternative, the Waste Receiving and Preparation Facility (WRPF), the Thermal Desorption Facility (TDF) or the non-TRU Incineration Facility (IF), and the Interim Storage Facility (ISF).

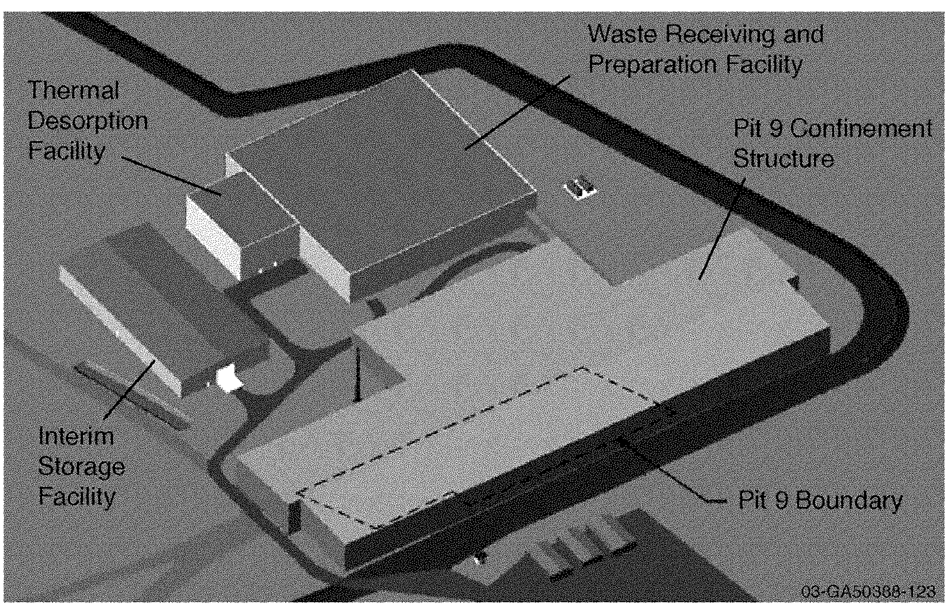

Figure 7. Physical layout of the proposed treatment and retrieval facilities for the Pit 9 remediation project.

2.1.1 Process Description

Alternative 1 provides the minimum treatment to cost-effectively meet the requirements for disposal at WIPP or return to the pit by segregating the waste into TRU and non-TRU streams, compacting and packaging the TRU waste for disposal at WIPP, and treating the non-TRU material before returning it to the pit. Due to the addition of new packaging, and the relative incompressibility of soil, the overall volume reduction of this alternative is negligible. The operations for Alternative 1 take place in the WRPF and the TDF. See the process descriptions in the Appendix A and Appendix B for additional descriptions.

Material (waste and soil) is brought to the WRPF sorting deck from the Retrieval Facility. The sorting deck is a stainless steel structure 75 ft long and 25 ft wide located 15 ft above grade. Material is moved along the short side of the deck using a “walking floor” conveying system (see Appendix A for a description of this equipment). As the material is moved across the deck from the retrieval containers, operators in a clean operating area above the deck (see Figure **8)** use remotely operated equipment to effect a gross separation of waste and soil. Waste requiring special handling (oversize material, intact drums, and special case waste) is distributed to the appropriate glovebox for more detailed operations. The remaining waste is placed on a conveyor and transferred to the shredder.

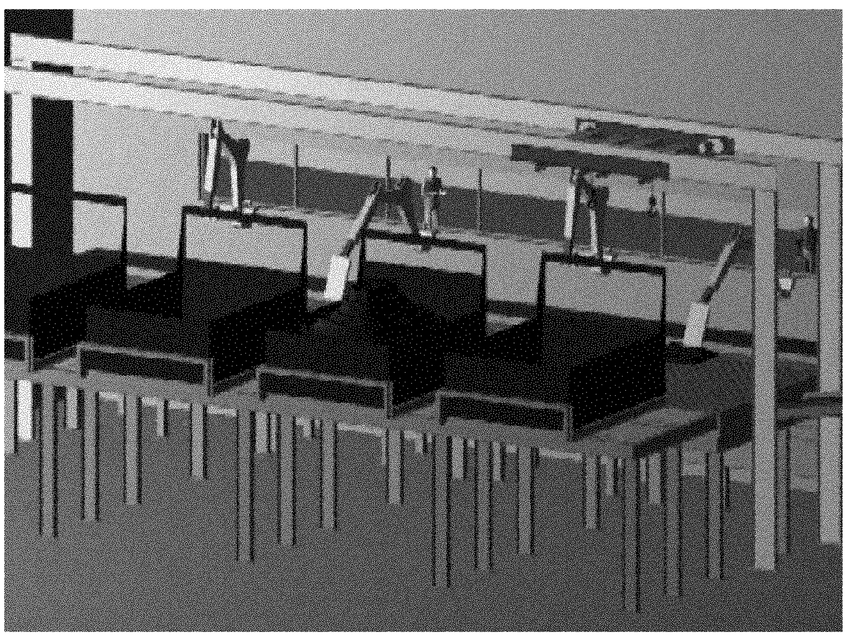

Figure **8.** The sorting deck is used to separate the waste and soil using arms controlled remotely by an operator behind impact resistant windows.

Oversize material is passed to the Oversize Material Enclosure where it is reduced in size and placed in an insert designed to fit within a WIPP standard waste box (SWB). The exterior of the insert remains clean allowing uninhibited transport through the clean operating area to the assay station. Containers that have TRU contamination levels less than or equal to 100 nCi/g are staged for return to the pit. Containers that are contaminated with TRU at greater than 100 nCi/g are sent to the ISF for container aging prior to heads-pace sampling to meet the WIPP WAC.

Intact drums are sent to the drum processing glovebox where they are opened, the contents examined, and all material, except special case waste, is transferred to the shredder. Special case waste is waste that cannot be treated to meet the applicable WAC. This material is packaged and will be stored until a disposition path can be identified. It is anticipated that there will be only small volumes of special case waste encountered in the Pit 9 retrieval.

The material destined for shredding is fed, via a conveyor, to a two-stage shredder. The output of the shredder is routed to a shredded material packaging (SMP) glovebox. In the SMP glovebox, samples of the shredded material are taken for analysis for VOC contamination. After sampling, the shredded waste is placed in 55-gallon drums. Visual examination of the waste is performed during packaging to verify it complies with WIPP WAC requirements. The drums are then assayed for TRU and uranium content. Drums that are determined to be greater than 100 nCi/g TRU are sent to the compactor cell for compaction and overpacking. Drums that are contaminated with TRU at levels less than or equal to 100 nCi/g and are below action levels for uranium and PCBs, and do not have VOC contamination above the trigger level, are staged for return to the pit. Drums of shredded material with VOC contamination are transferred to the TDF for processing.

The compactor cell is envisioned to be very similar to that being commissioned for the AMWTP. Assuming a difference in volume of 2,700 m^3 between the compacted and non-compacted waste (see the Mass Balance Spreadsheet in Appendix H, *Pit 9 Alt 1 Compact All.xls*), and a total WIPP transportation and disposal cost of \$76,000/m^3 (BBWI, EDF-3711 2003) the difference in disposal costs for compacted and non-compacted waste is over \$200M. The drums are transferred from the clean operating area through a drum entry airlock into the compactor cell where a super compactor substantially reduces their volume. The resulting compacted shapes, called pucks, are then placed into an overpack container. While this feasibility study assumes a new compactor cell in the WRPF, it will undoubtedly be more economical to use the AMWTP facility system. Discussions will be held with BNFL to explore this possibility.

Containers to be returned to the pit have the void spaces filled with a thin grout at the stabilization glovebox station to reduce the possibility of subsidence of the future SDA cap. The grouted containers are placed in a 5 x 5 x 6 ft box where more grout is added to fill the void spaces in the box. The grouted boxes are passed, via an airlock, to the retrieval transfer corridor for transport back to the pit using the retrieval equipment.

After the intact drums, oversize objects, and general debris are removed from the sorting deck, the remaining soil and small debris is dragged or moved by the walking floor to the inboard side (away from the side of the deck on which material is deposited) of the deck. The deck has a 4 ft wide slotted grate that extends the full length of the deck. The soil and small debris fall through this grate to a collecting conveyor that moves it to the soil screen feed conveyor. The soil feed conveyor deposits the soil and the small debris onto the soil disc screen. Soil passes through the disks while larger material remains on top of the disks and ultimately (due to the incline of the screen) passes to the oversize transfer conveyor where it is then conveyed to the shredder and processed with the rest of the waste.

The soil that passes through the disc screen is transferred, via the screen product transfer conveyor to the soil hoppers providing a small amount of surge capacity. Soil from the hoppers is then transferred via conveyors and vibrating feeders to the conveyor belts of the soil assay units. The soil will be deposited on the conveyor in a uniform depth (approximately 4 inches) allowing the assay system to completely determine the TRU content of the soil. The soil is then discharged into SWB inserts. A soil assay unit totalizes the TRU content of the material determining the TRU content of the soil in the container. Samples will also be taken from the belt for analysis for VOCs. Soil containers that contain

TRU at levels greater than 100 nCi/g will be packaged in SWBs and placed in interim storage for container aging prior to head-space sampling. Soil containers that have TRU contamination that is less than or equal to 100 nCi/g and do not contain VOCs above the action level are staged for return to the pit. Containers that are to be returned to the pit are stabilized with grout prior to return.

Return to Pit Alternatives

Containers designated as non-TRU but containing PCBs or uranium contamination above the respective action levels will be placed in long-term storage. Containers that have material contaminated with VOCs above the action limit will require treatment for VOCs. This treatment could be either a low temperature thermal desorption process or an incineration process.

The low temperature thermal desorption process uses relatively low temperatures (less than 150°C for the final treated material) to vaporize the VOCs and water in the soil. The contaminated material is fed to a thermal desorption unit, which is a vessel that contains two heated augers or screws side-by-side. The screws are heated by circulating hot oil through the inside of the hollow screw. Material is fed at one end of the unit and slowly moved through the unit and heated by the action of the screws. Material exits the unit at about 175°C, sufficiently above the boiling point of water and above the boiling point of the VOC contaminants; this assures that the VOCs have been removed from the final product. Other organic material with higher boiling points (such as the Texaco Regal Oil) will not be removed from the material. This material is passed through cooling augers, packaged, and returned to the WRPF for stabilization and return to the pit.

The VOC vapors and water vapor that are generated during the heating process are swept from the thermal desorption unit using a small flow of steam. These vapors are condensed and collected in a tank. The VOCs, which are heavier than water, settle to the bottom of the tank where they are drawn off to the VOC storage tank. The water remaining in the tank after the VOCs are drawn off is cleaned of trace VOCs by passing it through granulated activated carbon (GAC) and is then evaporated. The steam is passed through a high-efficiency particulate air (HEPA) filter and exhausted to the facility stack. The reclaimed organic material is transferred to drums and can be shipped offsite for treatment or stored until an on-site facility is available. Additional detail on the thermal desorption process is provided in Appendix B.

The incineration process (dirt burner) involves using a rotary kiln type incinerator to subject the contaminated material to high temperatures that will evaporate the water in the feed material, evaporate and partially oxidize any VOCs, and oxidize any combustible material. The off gases generated in the rotary kiln are drawn into the secondary combustion chamber where they are completely oxidized. The gases from the secondary combustion chamber are then routed to the off gas treatment train, which includes the air pollution control equipment needed to reduce the contaminants to comply with the requirements of the Maximum Achievable Control Technology (MACT) standards for Hazardous Waste Combustors. Additional detail regarding this process is provided in Appendix D.

2.1.2 Facility Descriptions

There are three major facilities associated with the Alternative 1, the WRPF, the TDF or the IF, and the ISF. In the WRPF, material from the Retrieval Facility (INEEL 2003) is received, segregated into waste and soil streams for assay, and assayed. The TRU stream is prepared for disposal at WIPP and the non-TRU stream is treated as necessary and returned to the pit. The TD facility houses the equipment needed to treat the non-TRU stream that is contaminated with VOCs. The ISF provides storage space for the TRU fraction, mainly to meet drum-aging criteria. Descriptions of these facilities are provided below Plans and sections of these facilities are provided in Appendix I.

Architectural Descriptions

Waste Receiving and Preparation Facility

The WRPF is approximately 250 ft square and 45 ft high. It has been designated as an International Building Code (IBC) low hazard factory F1 occupancy that requires a Type IB construction with 2-hour fire separation. A detailed assessment of the occupancy will be performed in subsequent design efforts. To achieve the 2-hour separation and assure the proper fire separation between other facilities, the WRPF will be constructed of 12-in. thick concrete walls. It has been assumed that structural columns would be located on a 25 ft grid to support the roof. The floor will be slab-on-grade construction and there will be minimal under-slab utilities. Walls will be covered with epoxy coating to facilitate decontamination. The main area of the WRPF is a large open area that houses the conveyor and equipment enclosures. The large dimensions of the WRPF are dictated, to a large extent, by the lengths of conveyors that move material from the sorting deck to other process enclosures. These conveyors are limited to a rise of 10" to 12°, and therefore require relatively long distances to raise the material to the required heights. Adjacent to the sorting deck is an enclosed mezzanine area for the operators who are conducting the sorting operations. Their vantage from this mezzanine looks down on the sorting deck to facilitate operations. An office and control room is located on the west side of the facility. The WRPF also contains an enclosed area for loading TRUPACT IIs and the Mechanical, Electrical, and heating, ventilating, and air conditioning (HVAC) rooms.

Thermal Desorption Facility

The TDF consists of a high-bay processing cell, an effluent treatment and off gas equipment cell, an in-feed and lag storage area, a repackaging cell, a control room, and various facility utility areas and office space. It has been designated as an IBC low hazard factory F1 occupancy that requires a Type IB construction with 2-hour fire separation. These areas will be constructed of structural steel with insulated metal panels.

The core processing area of the TDF houses the thermal desorption equipment. This cell covers about 2,000 ft^2 and is 50 ft high. It contains the in-feed hopper and auger, the thermal desorber, and the out-feed cooling screw and auger. High overhead clearance in this area is required to transport the intermediate bulk containers with debris to the in-feed hopper. A 25-ton overhead bridge crane services this cell with reach capabilities of handling the heaviest equipment. Manned access to this cell is gained through an airlock.

The effluent treatment and off gas equipment cell covers about 1,800 ft^2 and is 50 ft high. This area contains the primary condenser, the separator tank, the VOC storage tank, the GAC beds, the HEPA filtration system, the evaporator, and associated pumps. An overhead 10-ton crane provides maintenance services for this area. Airlocks are positioned at each end of this cell for manned access.

The receiving and lag storage area is approximately 2,000 ft^2 and 30 ft high. This area is designed to store 24 intermediate bulk containers. This lag storage will allow the thermal desorber (TD) to remain on-line if for some reason the retrieval systems go down. An airlock is utilized to transfer the intermediate bulk containers from this area to the high-bay processing cell. A forklift transports the bulk containers into the airlock. Inside the airlock is a monorail 5-ton crane that lifts the bulk containers and moves them into the processing cell through another set of containment doors.

The repackaging cell covers about 2,300 ft^2 and is 30 ft high. This area contains the out-feed hopper and the box-loading auger. Hard boxes measuring 5 × 5 × 6 ft are loaded with the out-feed product of the thermal desorption process and prepared for placement back into the pit. Special loading equipment will assure proper filling of boxes in this area through a specially designed glovebox. A forklift will be used to position the boxes under the filling station glovebox. This area has a box airlock that interfaces with the loading station and floor space to store four additional boxes. Inspection operations of loaded boxes and preparations for transport to the repository take place in this area.

A control room of about 600 ft^2 will contain the control consoles for the processing operations. Windows on one side will allow for viewing some operations in the effluent treatment and off gas equipment cell. Operators will monitor and control each piece of equipment from this control room.

Utility Housing

Mechanical and electrical utilities will be housed in two separate areas. The mechanical room is approximately 280 ft^2 and the electrical room about 180 ft^2. Both of these areas have large forklift access doors for equipment installation and maintenance. Electrical switchgear and motor controls will be stationed in the electrical room and facility off gas equipment including filtration equipment will be in the mechanical room.

A boiler room houses a small propane fired boiler that produces the steam that is used as the sweep gas for the thermal desorption operation.

Non-TRU Incineration Facility

The IF is about 140 × 110 × 75 ft high (see Sheet 1-A-6 in Appendix I). It has been designated an IBC occupancy classification F1. It is constructed of structural steel and insulated metal panel. The floors are impervious concrete slab. The major areas in the IF are the feed staging room, the incinerator room, the ash handling room, the off gas treatment room, the mechanical and electrical rooms. There is also some limited office space. The overall height of the facility is dictated by the arrangement of the off gas treatment equipment and feed handling requirements.

Interim Storage Facility

The ISF design is based on the existing Type II Storage Modules located at the RWMC. A Type II Storage Module is approximately 120 × 240 ft with an eave height of 27 ft and a peak height of 32 ft-10 in. Due to changes in the IBC, this facility will have an occupancy classification of S2. Like the Type II Storage Modules, the ISF is a metal building system, clad with ribbed metal siding and standing seam metal roofing. It is constructed over an impervious, curbed concrete slab designed to provide a basin for liquid waste containment. A cutoff wing on the west side of the building houses small electrical and fire riser rooms. The wing is separated from the main storage building by 2-hr fire-rated construction (gypsum board on metal frame with properly sealed penetrations).

Structural

There are three main structures associated with Option 1. The WWF is constructed of structural concrete shear walls and reinforced concrete beams and slabs. The other facilities will be structural steel frames. The walls will be modular steel panels and will be painted or lined with 16 gage stainless steel sheets, depending on the service and the potential for decontamination.

Interior corridors, exit pathways and stairways will be framed with metal studs where necessary. Heating and ventilation rooms, decontamination areas, airlocks, and other structures will use structural steel for their main framing system.

The WWF is assumed to be safety significant. The performance category (PC) is assumed to be PC-2. Other facilities are currently assumed to be PC-1.

The major structural systems will be designed to

- Support applicable loading form personnel, equipment, other minor structures, and supports systems and components as required by applicable codes and standards
- Support applicable natural phenomena loading per the applicable DOE performance category requirements and per the requirements of the IBC
- Withstand negative pressures imposed by the ventilation system, including both normal and maximum operating pressure.

The major design standards, codes and specifications used for design for the treatment structures are the *DOE-ID Architectural Engineering Standards, International Building Code,* the American Institute of Steel Construction's (AISC) *Speczjcationfor Structural Steel Buildings-Allowable Stress Design* and other AISC specifications such as the *LRFD Speczjcationfor Structural Steel Buildings.* Any concrete used this project will comply with the requirements of the American Concrete Institute (ACI) 318, *Building Code Requirements for Reinforced Concrete* or ACI 349, *Code Requirements for Nuclear Safety Related Concrete Structures.*

Mechanical

WRPF Systems

The sorting deck is made up of six sections of walking floor conveyor, each one measuring 12 ft wide × 20 ft long. These units are produced by Keith Manufacturing Co., a supplier of walking floors to the agriculture, waste, energy, and other industries. Each floor section is made of 5-in. wide stainless steel slats and driven by individual electric hydraulic power units. Specially engineered seals reduce debris buildup between the slats and help keep dirt from sifting under the floor. There is an interlocking leak proof subdeck to prevent the escape of liquids. To make the bulk material move (see Figure 9)[1], all floor slats move together carrying the load with them. At the end of this stroke, the first group of every third slat moves under the load. The weight and friction of the material against the surface area of two sets of slats is greater than the weight and friction of the material against a single third set of slats and holds the

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[1] Figure 8 is used by permission of KEITH Mfg. Co. (© 2003, KEITH Mfg. Co. All rights reserved).

waste in position. Then the second group of every third slat moves under the load. Lastly, the final group of every third slat moves under the load. The cycle is then repeated as all the slats move forward together conveying the load. Each section of floor is designed to carry approximately 20,000 lbs at a rate of 12 ft per minute. See Appendix A for additional information on the walking floor.

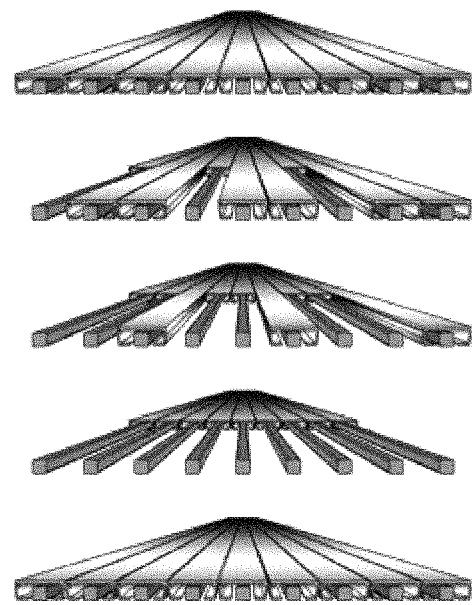

Figure 9. The walking floor conveyors move the bulk material across the sorting deck.

There are three remote controlled electro-hydraulic driven material handling arms servicing the sorting deck. These handling arms are based on a Brokk 330N demolition robot and supplied with a steel shear, a clamshell bucket for sorting and grabbing, a loader bucket for spreading, and a tool rack carousel. Operators control the handling arms from an isolated control room located above the sorting deck. Each arm can reach the length of the walking floor to the retrieval containers and is capable of rotating 180° perpendicular to the walking floors.

Loose soils and waste are moved by a combination of the walking floors and the material handling arms to a stationary grizzly screen that is simply a roughing screen with 4 in. × 4 in. openings. The screened material drops through the grid, through a tapered hopper, and onto the soils collecting conveyor. This conveyor is a 4 ft wide × 120 ft long apron conveyor with a separate dribble drag cleanup conveyor. The apron conveyor is constructed of a series of steel pans with crimped edges to ensure minimal material loss. The drag conveyor moves material that has fallen from the apron conveyor to the screen conveyor by a chain with paddles attached. The collection conveying system is enclosed with the enclosure having viewing windows and glove ports provided for maintenance.

The rough screened material is transported to the soil screen by the screen feed conveyor (see Figure 10). The screen feed conveyor is an apron conveyor 4 ft wide × 130 ft long rising approximately 25 ft. The screen feed conveyor's total capacity is 15,000 lbs and the conveyor travels at 0.5 fpm. It also has a dribble drag conveyor underneath to collect any spillage. The whole system is totally enclosed with viewing windows and glove ports for maintenance access.

The soil screen is an inclined disc screen aligned with and the same width as the screen feed conveyor. The soil screen consists of a series of driven shafts that turn in the direction of material flow. The shafts are mounted with discs, arranged in rows along the length of the shaft. As the soil and waste pass over the turning discs the smaller soil material (60 mm and smaller) falls out between the discs into a collection hopper. The larger waste material is carried across to the screen rejects transfer conveyor.

The collection hopper meters soil onto the screen product transfer conveyor that delivers it to the soil surge storage bin. The screen product transfer conveyor is an apron conveyor 3 ft wide × 150 ft long rising approximately 15%ft. Its capacity is 9,000 lbs and travels at 0.5 fpm. It has a dribble drag conveyor underneath to collect any spillage. The whole system is totally enclosed with the enclosure having viewing windows and glove ports for maintenance access.

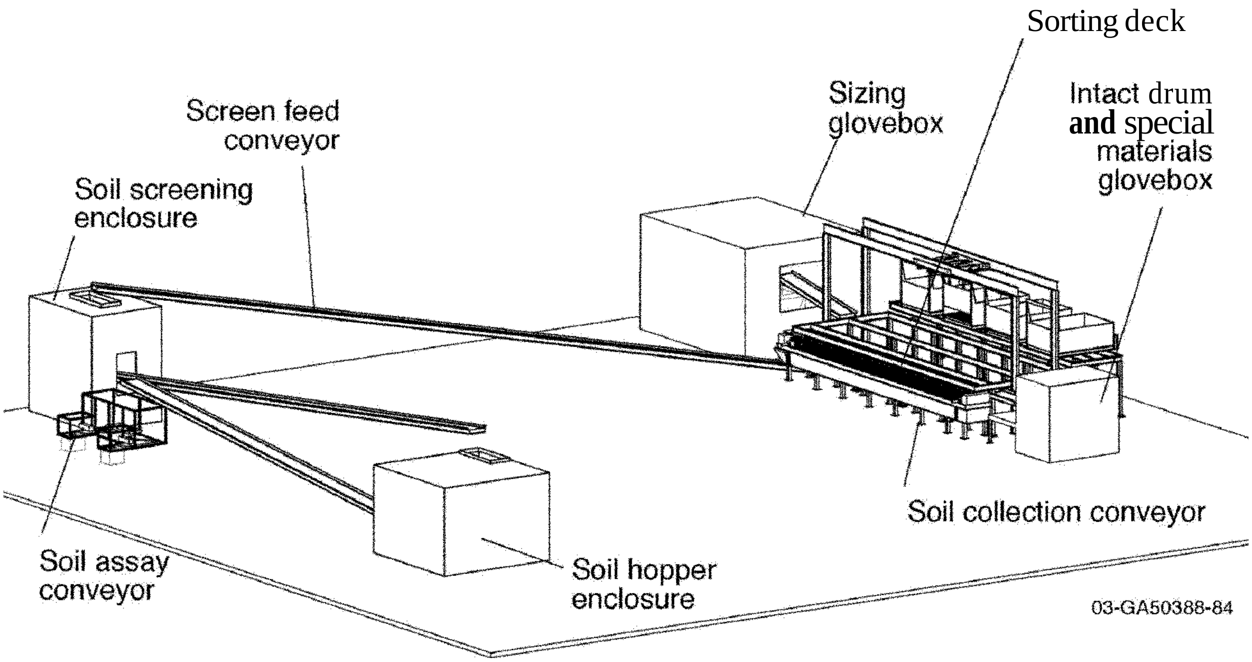

Figure 10. The conveyors in the Waste Retrieving and Preparation Facility move the waste through the assaying and separation processes.

Oversize material (greater than 60 mm) from the disc screen is transferred by conveyor to the shredder for sizing before going to the assay station. The conveyor will be a troughed bed conveyor 3 ft wide × 130 ft long rising approximately 3 ft to the shredder. Its capacity is 5,000 lbs and travels at 0.5 fps. The troughed bed type conveyor is suitable for bulk material that could have fines in it or is fragmented so that it could get under the belt. The unit is totally enclosed with the enclosure having viewing windows and glove ports for maintenance access.

In addition to the material handling arms, a remote controlled underhung double girder system 7%ton capacity bridge crane services the entire surface area of the sorting deck. Attachments for a grapple, sampling, apparatus, camera(s), spray nozzles for dust control, and instruments are included. A specially designed basket hung from the crane will accept unit items of waste and move them laterally to the conveyor servicing the specific treatment glovebox. An intact sludge drum weighing 700 lbs is the heaviest waste item expected to be handled in this manner.

Objects too large to be handled by the shredder will be placed on the oversized material transfer conveyor for delivery to the sizing cell. The transfer conveyor is a slat type conveyor measuring 4 ft wide × 30 ft long and rising 4 ft discharging onto the shear feed conveyor. The slat conveyor offers a flat surface that is higher than the side frames allowing access to load or unload from the sides. The slat conveyor's capacity is 1,000 lbs and it travels at 0.5 fps. The sizing cell includes the shear feed conveyor, a remotely and automatically operated hydraulic guillotine shear, an underhung 5-ton bridge crane covering the entire cell, the shear discharge conveyor and SWB insert and 55-gal drum loadout ports. Both the shear feed and discharge conveyors are slat conveyors 3 ft wide × 10 ft long with the feed conveyor incorporating a pusher discharge arm mechanism. The shear is an industry standard scrap shear with a fixed lower blade and an inclined upper blade.

Intact drums are removed from the waste and transferred to the drum processing glovebox by a 30 in. wide × 30 ft long apron conveyor. The drum processing glovebox is a modified HANDS-55 glovebox that provides a remote, modular waste conditioning system integrating waste sorting, repackaging, waste reduction, and control. The glovebox includes a turntable with a discharge chute, two drum handlers with automatic de-lidding and dumping capabilities, two crane mounted robots with various end affecters for sorting drum contents, and two vibrating conveyors that act as drum contents sorting tables. These conveyors are 4 ft long × 15 ft long and move material to the drum contents collecting conveyor.

Loose waste not intended for the soils screening process is removed from the waste pile on the sorting deck by operators using the material handling arms and placed on the primary shredder feed conveyor. The primary shredder feed conveyor is an apron conveyor 5 ft wide × 130 ft long rising approximately 18 ft. Its capacity is 10,000 lbs and travels at 0.5 fpm. It has a dribble drag conveyor underneath to collect any spillage. The whole system is totally enclosed with viewing windows and gloveports for maintenance access.

The shredder reduces the loose waste material from the sorting deck and the rejects from the soil screen to pieces smaller than 60 mm. The selected shredder unit is a KOMAR tri-auger model GPT-3-400. This system uses a large dual auger as the primary shredder, the dual auger is mounted over a large single compression auger, making up the tri-auger portion of the system. A fourth auger, which is an injection auger, is mounted at a right angle to the discharge of the large single compression auger providing hrther grinding and reduction. The shredder discharges to the shredded waste transfer conveyor. The shredder system is hlly enclosed and operates under a nitrogen purge. The unit is sized to handle large wooden fiberglass covered boxes. The shredder is also used to size any large soil chunks and blocks of solidified sludge. This material is sent to the soil/sludge surge storage bins via the soil and sludge conveyor. The conveyor is an apron conveyor 3 ft wide × 130 ft long rising approximately 22 feet. It is equipped with a dribble drag clean-up conveyor beneath to catch any overspill (see Figure 11).

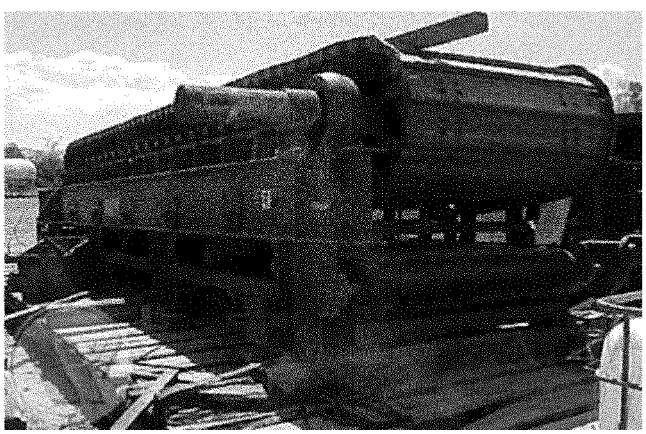

Figure 11. Apron conveyors are equipped with a dribble conveyor that catches overspill.

The shredded waste transfer conveyor is an apron conveyor 3 ft wide × 50 ft long carrying the sized material to either of two drum filling vibrating conveyors located in the drum filling and packaging glovebox. Each of these vibrating conveyors is 18 in. wide × 5 ft long and provides material at a controlled feed rate to the drum loadout ports. The drums themselves remain external to the glovebox and clean and are sealed to the glovebox using the double door transfer concept. A lift table with scale is used to position the drum against the glovebox. Once filled, the drums are transferred via chain driven live roller conveyors to the container assay units for fissile material determination. Those drums reading greater than 100 nCi/g are sent to the super-compactor.

The super-compactor is a large hydraulic press used to crush a drum containing shredded waste. The container is held in a mold during the compaction stroke of the super-compactor, which sizes the container's outer dimensions. The compressed drum is stripped from the mold and the process repeated. The compactor is capable of producing a force of 100 tons or more to crush a drum into a hockey puck in a manner of minutes. Included in the compaction glovebox is a container ejection system and loading system that will move the crushed containers and place them (two or more) in an overpack container for storage and ultimate disposal.

Each TRU alternative must be combined with one of the non-TRU alternatives to complete the overall treatment scheme. The non-TRU material that is contaminated with VOCs at levels greater than the action level is transferred to either the non-TRU incinerator (Alternative 2aP) or the non-TRU TDF.

TDF Systems

The non-TRU TDF consists of two major subsystems, the soil treatment system and the vapor liquid-system. The soil handling system consists of the feed system, the thermal desorber, and the treated material discharge system. Material is brought to the TDF in re-useable stainless steel bulk transport containers. The loaded bulk containers are transported either by overhead crane or by forklift to the thermal desorption feed hopper and un-loaded. Each bulk container is equipped with double-lid type openings on the top and bottom to facilitate alpha contamination control during loading and un-loading. The bulk containers can be easily decontaminated for control of radioactive materials. The bulk containers can be stacked two high where floor space is ample enough for forklift access. Material is transferred from the bulk containers to the feed hopper, which allows the TD to be fed continuously. The hopper is sized to hold 24 hours of feed or approximately 20 cubic yards of material. The hopper will be coupled directly to the desorber to reduce the flow of air into the TD system. The hopper is equipped with an isolation valve and a metering valve. The hopper top port is designed to receive a bulk container and interface with the double-lid system for unloading. The interfacing of the bulk container and the hopper is accomplished using positioning studs and a seal. A small interface glovebox surrounds the top of the hopper and the bottom of the bulk container so that matting surfaces can be monitored and decontaminated as needed prior to movement.

The thermal desorption unit selected for this study was a "Holo-Scru" Dryer manufactured by Unico Services, Inc. This unit can easily be sized to meet the Pit 9 requirements. The process can also achieve the negative pressure or vacuum, and eliminating fhgitive emissions from the system. The "Holo-Scru" Dryer circulates hot oil at or below 250°C through two hollow flight screws, heating the waste as it is moved through a jacketed W-trough housing. The hot oil is circulated through a propane-fired heat exchanger after it has exited the hollow-flight screws. The screws have 20-inch nominal diameter flights, a 20-foot working length with a 6-inch pitch mounted on 10-inch pipe shafts. The material of construction is stainless steel. Shaft seals are designed to prevent loss of material or gases from or the flow of gases into the system. Residence time for the debris is controlled by the speed of the screws and is adjustable such that the debris reaches the desired temperature while in the desorber. A 15 horsepower motor couples with an in-line speed reducer and a set of timing gears provides the driving force to move the soil through the desorber.

The desorber is operated at negative pressure to eliminate fhgitive emissions. Steam is used as sweep gas to move the vaporized organics to the condenser. A boiler supplies superheated steam to the dryer at approximately 39 kg per hour. Use of steam as the sweep gas will increase the load on the condenser, but decrease the load on the off gas system. Only non-condensables entering with the waste and fhgitive condensables will go into the off gas system. The condenser used in this design is a Graham Corporation shell and tube condenser that will handle the vapor streams generated by the thermal desorber. The Graham VCT Heliflow Vent Condenser condenses the vapor stream on the tube side, giving more positive control of the possibly radioactive stream. This unit allows condensate to be piped into a tank, instead of draining off the outside of the tubes into a catch tank, giving more positive control of the condensate. The vent condenser will operate at the required negative pressure. Design vapor inlet temperature will be 175°C, while condensate temperature will be 50°C. The design throughput for the condenser is 311 kg condensate per hour, assuming 93% water and 7% organics. This rate will allow sufficient additional condensing capacity to account for unforeseen moisture in the waste. A condensate pump is used to transfer thus liquid to the organic settling tank. The condensate pump is sized at 4 gpm for worst case flow.

The organic separator tank is a 600-gallon stainless steel tank provided with Teflon baffles to aid in separation. A sight glass will allow the operator to drain the organic phase from the tank.

The organic phase is collected in a storage tank and, when desired, will be transferred into drums for disposal off-site. This 70-gallon tank holds over three days worth of organic liquids if the organics were spread evenly through the waste.

Water coming from the settling tank is pumped through a Bonifiber bed, a carbon bed and to an evaporator to remove any trace organics. The Bonifiber bed is used as an initial sorption step to separate the organics from water. Bonifibers adsorb 25 times their weight in organics, normally oil. Traces of oil and similar organic compounds are removed in this step. Bonifibers do not work well on halogenated hydrocarbons so a carbon bed will be required. The low flows of water from the process allow the use of drummed carbon beds. Selected Adsorption Associates and others market these drums, used in series, for flow rates up to 10 gpm. Using four drums in series will allow the first drum to be hlly saturated before it is changed out. The water is then evaporated and released to the environment as steam. The evaporator and heat exchanger combination convert the bulk water flow from the carbon beds to water vapor, which is monitored and sent up the facility stack. Any remaining water that condenses to the bottom of the evaporator is feed back to the thermal desorber.

The treated solid material leaves the desorber unit at about 175°C so it must be cooled before it can be packaged for return to the pit. A cooling screw auger is used to accomplish this. The auger has an 18-in. diameter hollow flighted screw housed within a 20 ft jacketed U-trough chamber. The screw flights have a 6 in. pitch and are welded onto an 8 in. pipe shaft. The screw receives facility water at 75°F and indirectly cools the thermal desorbed waste from 300"–100°F. This screw is fabricated from stainless steel and designed for a pressure of 100 psig. A 5 HP drive motor and inline speed reducer rotate the screw. The cooled material is discharged to the Out-Feed Hopper by another transfer auger. This hopper is similar in design to the feed hopper but sized for 15 hours of storage capacity and is approximately 6 ft square and 10 ft tall. The treated material is packaged for transport back to the pit in the Repackaging Station Glovebox. This stainless steel glovebox is approximately 15 ft long, 8 ft wide, and 8 ft tall and is structurally supported some 6 ft above the facility floor. A bag interface port adapted for the 5 ft by 5 ft by 6 ft boxes is used to provide primary containment while boxes are being filled. The glovebox design incorporates gloveports, ventilation, and lighting. A box positioning system under the glovebox allows for operators to reposition the box while filling. This positioning system consists of a cart on tracks that can be easily moved in the X, Y, and Z directions.

Incineration Systems

The other non-TRU treatment alternative is the non-TRU incinerator. This incinerator (essentially a dirt burner) subjects the feed to high temperatures, destroying the VOCs, oils, and any other combustible material. The major components in this system include the primary combustion chamber, the secondary combustion chamber, and an off gas treatment system that is compliant with the MACT rules. The primary combustion chamber is a 1.6 m ID, 11.6 m long refractory-lined, rotating kiln. The kiln is slightly inclined so that as it rotates the material moves from the feed to the discharge end. The kiln is directly fired with propane, which heats, evaporates, and oxidizes (or partially oxidizes) the material in the kiln. The gases driven off in this heating process pass to the secondary combustion chamber, a 1.6 m ID refractory lined cylindrical vessel that is sized to provide a 2 second residence time at 1,100°C. It is also directly fired with propane.

The hot gases then pass to the off gas treatment train. The two water-cooled cyclones are 1.3 m in diameter and 2.5 m long, (not including the inlet transitions). The cyclones remove larger particulate matter before the gases pass to the scrubber sections where they are then quenched in an Alloy C-276 quench and scrubbed of gaseous and particulate contaminants. A portion of the scrub solution must be blown down (tapped off) to reduce the level of contaminants in the solution. This scrub blowdown is evaporated to reduce its volume and stabilized by grouting. It is expected to be disposed of as hazardous low-level waste. After the scrubber, the gases pass through a bed of GAC to remove any mercury, in case it is present in the waste. Finally, two stages of HEPA filtration to remove the remaining particulate from the stream and nitrogen oxides are removed in the selective catalytic converter (SCR). The SCR uses anhydrous ammonia and a solid catalyst to convert the NO_x to nitrogen, oxygen, and water vapor. There may be some small amount of ammonia gas in this stream as well. The gases are monitored by a continuous emissions monitor, as required by the MACT rules, before being exhausted out the facility stack. The dried soil and ash from the kiln pass into a cooling section before being packaged in 55-gallon drums in the drum loading enclosure. Additional detail on this system is provided in Appendix D.

HVAC and Utilities

The heating, ventilation, and air conditioning system for WRPF is divided into four contamination control zones, as required in the DOE-ID Architectural Engineering Standards. The contamination control zone designations at the INEEL are different than the rest of the DOE complex in that the most contaminated zone is designated Zone III at the INEEL (Zone I elsewhere), the least contaminated is designated Zone I (Zone III elsewhere), and clean areas are designated Clean Areas (Zone IV elsewhere).

The Zone III areas and systems in the WRPF include the transfer corridor, sorting deck area, all gloveboxes or primary enclosures such as the shredder and compactor enclosures, and all the conveyor enclosures. This system maintains the pressure inside these primary confinements at least 0.5 in. wc below that of the surrounding area and provides a minimum of 50 cfm per enclosure and will increase flow to accommodate loss of a glove and still maintain a minimum of 125 ft/min through the open gloveport on any enclosure.

The rest of the WRPF, except the office and control room, are designated as Zone II or Zone I systems, including the operating mezzanine. These systems are sized to provide a minimum of 100 cfm per ft^2 of floor space. The shift supervisor's office and control room are designated as Clean Areas.

Electrical

Power for the facilities will be provided via the existing INEEL 138kV Substation 9 located north of the proposed facilities. This substation was originally built and owned by LMAES but is now DOE property down to the secondary 4160V cable that feeds the LMAES powerhouse. The total capacity of the existing substation is 12MVA. A new powerhouse will be required to service the treatment and retrieval facilities. This powerhouse will contain the required 4160V switchgear, standby generator, control power battery bank and relaying for the high voltage transmission system. The main service to the facility will consist of, at the least, one normal power feeder and one standby feeder from the 4160V switchgear in the powerhouse. The actual number of feeders and breakers in the switchgear line up will be determined during subsequent design efforts. The design for Alternative 1 in this report is based on two normal feeds and one stand-by feed to the facility. The facility will contain three power distribution systems. The main commercial feed will supply the electrical service via 4160/480V transformers for all the non-standby loads. The second feed will be the generator backed standby feeder that will supply the facility with standby power via a 4160/480V transformer. Applicable codes and standards do not require a standby generator, however, prudent design practices dictate the availability of a standby system. The generator will be classified as an optional standby generator as specified by NFPA 70, National Electrical Code. In addition to the normal and stand-by power system, the third feed will be a solid state UPS with a static transfer switch. The UPS will be provided with a 20-minute battery backup. Both the normal feed and the bypass feed to the UPS will be on standby power. The UPS will feed a 208Y/120 volt panel. The UPS and the panel will be located in the electrical room. The UPS will support voice paging/evacuation systems, environmental monitoring systems, and other critical loads identified by operations.

The electrical requirements for the two Alternative 1 facilities were analyzed and the demand determined to be 4768kVA for the 1-2aP alternative (Compact All of the TRU waste and incinerate the non-TRU waste) and 3417kVA for the 1-3aP alternative (Compact All of the TRU waste and treat the non-TRU waste using thermal desorption). The results of the analysis are shown in the following tables. In addition to these loads, the demand of 1762kVA normal power and 851kVA stand-by power required by the Retrieval Facility is added to the result to obtain the overall demand that will be connected to the existing equipment in Substation 9.

Table 1. Treatment facility 1-2aP demand loads.

Load Type	Normal Demand KVA	Power Factor	Stand-by KVA	Stand-by Power Factor
General Loads	175	80%		
Heat	1243	100%	233	80%
Ventilation	1760	80%		
Lights	122	80%	63	80%
Office Equipment	60	80%		
Process Equipment	728	80%	574	80%
Total	3911	90%	870	80%
Facility Total	4768			88.4%

Table 2. Treatment facility 1-3aP demand load

Load Type	Normal Demand KVA	Power Factor	Stand-by KVA	Stand-by Power Factor
General Loads	175	80%		
Heat	1472	100%		
Ventilation	350	80%	233	80%
Lights	122	80%	63	80%
Office Equipment	60	80%		
Process Equipment	1030	88%	58	80%
Total	3081	95.5%	354	80%
Facility Total	3417			93%

Three utilization voltages will be provided for the facilities. Transformers and load centers located near the WRPF will transform the 4160V to 480Y/277 volts. Transformers down stream will transform the 480 volts to 208Y/120 volts. The third utilization voltage will be determined during later design efforts. 4160Y/2400 volt service is desired as the third utilization voltage. Equipment selection and operating personnel preference will determine the voltage that will be used.

Electrical loads will be assigned voltages as follows:

- Motors 100 HP and larger - 4160V, 3 phase or 2400V, 3 phase
- Motors ½ HP to less than 100 HP - 480V, 3 phase
- Resistive loads - 480V, 3 phase
- Motors less than ½ HP 120V, single phase
- Miscellaneous loads less than 1 kVA - 120V, single phase
- Lighting - 277V single phase.

Lighting levels will conform to the Illuminating Engineer's Society handbook and standard practices at the RWMC. In general, the design will provide the following illumination levels:

- Work Stations – 70 foot candles
- Work Areas – 30 to 50 foot candles depending on activity
- Non-Work Areas – 10-foot candles, 50 where data is obtained.

Lighting in office areas and other low ceiling areas will be supplied by fluorescent fixtures. These fixtures will be operated at 277 Volts and will be locally switched. Motion detectors will be used in areas of low occupancy. Lighting in high bay areas will be supplied by metal halide fixtures operating at 277 Volts. The metal halide fixtures will be switched at the lighting panel. Emergency egress lighting will be in accordance with NFPA 101, Life Safety Code. In areas where illumination is provided by fluorescent fixtures, selected fixtures will be provided with integral battery back up. In areas where illumination is provided by metal halide fixtures, selected fixtures will be provided with a quartz lamp that will be used for emergency lighting. The quartz lamp will be connected to the UPS system or will be provided with an integral battery.

2.2 Alternative 2b (Melt All)

Alternative 2b (Melt All) employs a facility similar to the WRPF described in Alternative 1 to receive and characterize material retrieved from Pit 9. The TRU fraction is hrther processed in a Melter Treatment Facility (MTF) to achieve a greater volume reduction than was possible in Alternative 1. As in Alternative 1, the non-TRU material contaminated high concentrations of PCBs or uranium will be set aside until additional capability is provided as part of later projects. Non-TRU material that does not contain PCBs or uranium but is contaminated with VOCs is treated in a separate TDF and all the non-TRU material is returned to the pit. No ISF is provided in this alternative because it is assumed that container-aging criteria will be relaxed due to the high temperature thermal treatment. Descriptions of the process and facilities needed to support these functions are provided below.

2.2.1 Process Description

Some additional assumptions that were made to support this Alternative 2, these are identified below

- The final TRU waste form is the result of a high temperature thermal process and head-space sampling can be performed on a limited sampling basis. Retaining a large number of drums in storage for long periods of time to satisfy WIPP drum age criteria will not be needed.
- The melter will not be required to process PCBs and therefore does not have to meet the Toxic Substance Control Act requirements for PCB destruction.

A simplified block flow diagram of the overall process is provided in Figure 12. More detailed process flow diagrams are provided in Appendix I, sheets 2B-PF 1, 2, and 3. The Alternative 2b process starts with a WRPF very similar to that described for Alternative 1, except that there is no compaction system. Waste and soil are segregated on the sorting deck and conveyed to the shredder or soil screen, respectively. Waste and soil that is assayed and determined to be TRU waste is placed into re-usable intermediate bulk containers. These containers are 4.5 ft × 4.5 ft ×4.5 ft high and have specially designed double-lid closures that allow contamination-free transfer of material from the containers to the melter feed hoppers. The feed hoppers are equipped with auger-type discharge devices combined with alternating flapper valves that provide feed to the melter while eliminating potential "blow-back" of hot gases.

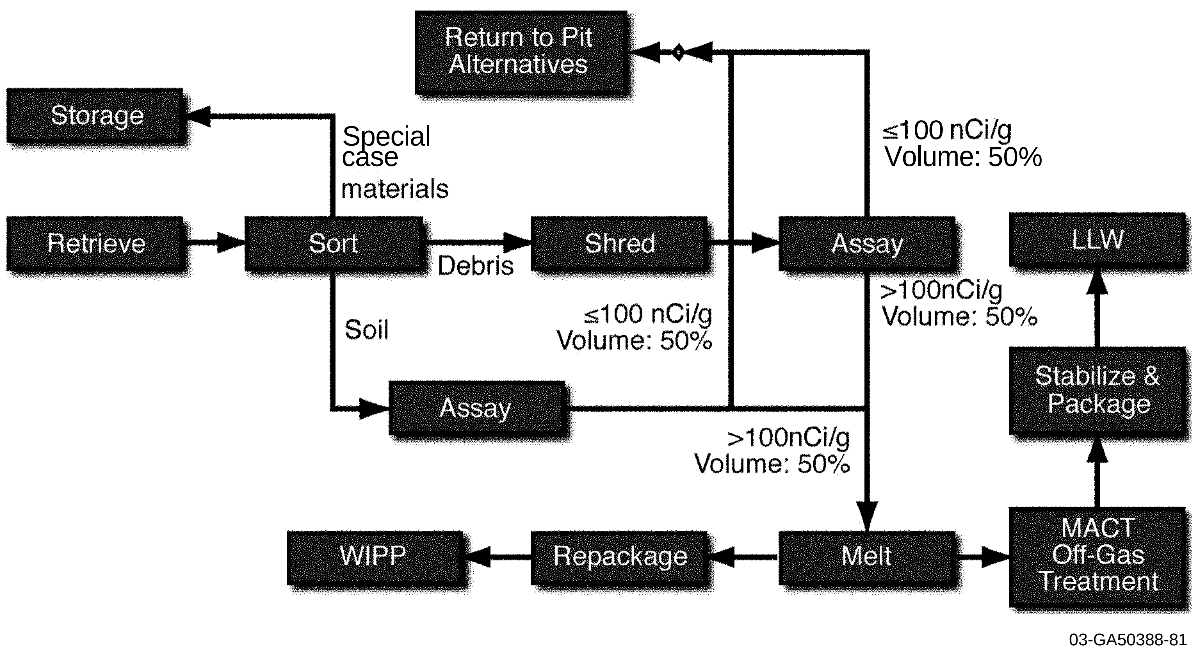

Figure 12. Alternative 2b (Melt All) process flow.

As noted in Appendix C, there are several types of melters available. The melter selected for the feasibility study is a fixed hearth submerged arc melter. In this type of melter, current passing between graphite electrodes heats the material in the hearth (called the melt) and maintains it in a molten condition. Solid feed material is introduced on top of the melt and is gradually subsumed into the melt. By controlling the feed rate a constant depth "cold cap" can be maintained on top of the melt, reducing the carry-over of volatile materials. As the material in the cold cap settles, it is dried, preheated, pyrolyzed, and finally melted. By controlling the feed composition and, if necessary, using an oxygen lance, the molten material will be maintained in an oxidized state. In other words, formation of a metal phase will be avoided. This is an advantage in that the oxidized material (called glass or slag) can be tapped (discharged) directly into metal drums because the heat transfer characteristics of the slag are such that the outer layer rapidly forms a solid skin (much like some lava flows) while the inner core more slowly solidifies. As the level of the molten material builds up in the hearth, it will be tapped into approximately 40-gallon drums from the bottom of the melter through a water-cooled valve. The size of these drums has been selected to minimize the number of containers produced but still remain below the WIPP weight limit of 1,000 lbs per payload container.

The drums of slag will take approximately 24 hours to cool from over 2,000°F to a surface temperature of about 120°F. This cooling will be accomplished by conveying the drums through a specially designed cooling chamber, sized to contain 50 drums (24 hours of production). After the 40-gallon drums are cooled they will be overpacked in 55-gallon drums and transferred to a storage area to complete cooling. The storage area has a capacity for 1,400 drums, or about 30 days of production. Drums will be taken from the this storage area, loaded into TRUPACT II shipping containers, and transported to WIPP for final disposal.

Off gas from the melter is routed through a secondary combustion chamber to assure that all gaseous products from the melter are completely oxidized. Downstream of the secondary combustion chamber are treatment subsystems for removing particulate, oxides of nitrogen, and other contaminants to comply with the applicable requirements of the Hazardous Waste Combustors MACT standards (40 CFR 63 Subpart EEE). The system is also provided with HEPA filtration to assure that particulate radionuclide emissions are reduced to acceptable levels.

2.2.2 Facility Descriptions

There are three facilities associated with Alternative 2b, the WRPF, the MTF, and the non-TRU TDF. Descriptions of these facilities are provided below.

Architectural Descriptions

The WRPF is very similar to that designed for Alternative 1, except that is does not contain a compactor. As noted previously, the overall size of the facility is dictated by the lengths of the conveyors used for soil and waste segregation, so there is no difference in the WRPF size compared to Alternative 1. The TRUPACT II loading station that was located in the WRPF has been moved to the MTF to minimize the handling of the product drums. The space in the WRPF can be used for surge storage or other operations.

The MTF is constructed of structural steel and insulated metal panel. It is also designated an IBC low hazard factory F1 occupancy that requires a Type IB construction with 2-hour fire separation. The MTF (and non-TRU TDF) occupy about 50,000 ft^2. The melter area of the facility is located adjacent to the WRPF to minimize feed handling distances. The melter area contains a waste and soil bin storage area, the melter itself, and the off gas treatment train. Directly below the melter is an area for tapping slag (or glass) into the metal drums. The tapping area extends 16 ft below grade. The overall height of the MTF is 75 ft (above grade) and is driven by the melter maintenance and feed system requirements.

A drum cooling area is located on the main floor to the east of the melter area. Here the drums of slag are conveyed in a cooling enclosure to an overpack station. The overpacked drums are transferred to the drum storage area. The drum storage area, located on the south of the MTF, provides storage for about one month's production (1,400 drums, stacked two high).

The HVAC systems are also provided on the south side of the MTF.

Civil/Structural

The WRPF structure nearly identical to the design discussed for Alternative 1. The MTF is constructed of structural steel and insulated metal panel and is expected to be a PC-2 structure.

Mechanical

The WRPF equipment is essentially the same as that described for Alternative 1 except that there is no compactor. In the WRPF, waste and soil that is contaminated with TRU at levels greater than 100 nCi/g are packaged in re-useable containers for transport to the MTF.

The melter itself is supported at grade level and surrounded by an access structure of structural steel. The first mezzanine above the melter supports the two electrode maintenance enclosures. These enclosures (diametrally opposed) consist of entry airlocks and equipment for handling the electrodes. As discussed in Appendix C, the electrodes are gradually consumed and must be lowered into the melt. At the end of the electrode life, the remaining stubs are removed and replaced with new electrodes. Above the electrode maintenance level is the melter feed access level. This level provides access to the melter feed system components. Finally, the top of the structure supports the waste and soil feed bins.

The drum filling area is located directly below the melter. Empty carbon steel drums (approximately 40-gallon capacity) are lowered into this area on one side of the melter and enter the drum filling enclosure. All filling and cooling operations are conducted inside contamination control enclosures (primary confinement). When the melter has processed sufficient material, a filling campaign will be initiated. Slag will be tapped directly into the drums. The drums will then pass through a cooling enclosure with water-cooled walls and forced air ventilation. To minimize the amount of below-grade excavation, the filled drums are raised to grade level after passing under the melter and continue cooling on grade. After the drums have cooled sufficiently (skin temperature less than 120°F) they are overpacked in 55-gallon drums, which are sealed and swiped to assure there is no external contamination. The 55-gallon drums are then assayed for WIPP certification and transferred to the drum storage area, which has a capacity of 1,400 drums.

Again, the non-TRU material that is contaminated with VOCs must be treated before being returned to the pit. Based on the cost data developed for the non-TRU alternatives, the thermal desorption system is much less expensive that the incineration approach so only the TDF was considered in this alternative. This TDF is the same as that described for Alternative 1.

HVAC and Utilities

The ventilation systems for confinement of radioactive contamination are designed in accordance with the DOE-ID Architectural Engineering Standards and the other standards referenced therein. The HVAC system for the WRPF is the same as that described in Alternative 1. See Sheets 2B-HV-1 through 3 for a schematic of the overall system.

The ventilation system for the MTF consists of three confinement zones. The Zone III system (the most contaminated) includes the drum filling and cooling enclosures, the overpack glovebox, and the feed and discharge enclosures in the non-TRU TDF. This system draws air from the surrounding Zone II areas through the enclosures, and through two stages of HEPA filters before reaching the Zone III exhaust fans. The exhaust fans discharge directly to the facility stack. The total flow of the Zone III is estimated to be 1,500 cfm. The fans operate at a pressure differential of about 15 inches of water. There are three installed fans, of which one is an in-place spare.

The Zone II system includes the drum filling room (which contains the drum filling and cooling enclosures), the drum cooling area on the main floor, the melter area, and the non-TRU TDF. Most of the Zone II systems are designed for six air changes per hour. This relatively high rate of air exchange is needed to control the temperatures in the operating areas. The overall Zone II system flow is about 80,000 cfm. In the case of the Zone II system, some air is drawn from the Zone I system but much of the air is provided by a set of air handling units (AHUs) that condition the air before supplying it to the Zone II areas. This air passes through the facility, is filtered by two stages of HEPA filters, and reaches the Zone II exhaust fans. Again, there are two operating fans with an in-place spare.

The Zone I system includes the drum storage area, the HVAC area, and the TRUPACT II loading area. This system operates much like the Zone I system, with essentially all of its air provided by the Zone I AHUs. The total Zone I system flow is about 32,000 cfm.

Electrical

Power for the Treatment Facility will be provided via the existing INEEL 138kV Substation 9 located north of the proposed Treatment Facility. The description and requirements stated in the Electrical section of Alternative 1 (see page 22) are applicable to this alternative with the change being the electrical load requirements. The electrical requirements for Alternative 2a-3aP (melt the TRU waste and treat the non-TRU using thermal desorption) facility were analyzed and the demand determined to be 7284kVA. The results of the analysis are shown in Table 3. In addition to these loads, the demand of the Retrieval Facility is added to the result to obtain the overall demand that will be connected to the existing equipment in Substation 9.

Table 3. Treatment facility 2b-3aP demand load table.

Load Type	Normal Demand KVA	Power Factor	Stand-by KVA	Stand-by Power Factor
GeneralLoads	175	80%		
Heat	2975	92.5%		
Ventalation	0	100%	932	80%
Lights	352	80%	63	80%
Office Equipment	60	80%		
Process Equipment	2754	83%	18	80%
Total	6280	87.7%	1013	80%
Facility Total	7284			86.8%

2.3 Alternative 4a (Thermal Desorption, Chemical Leach, Incineration)

Alternative 4a provides the treatment processes that achieve the highest volume reduction of the material shipped to WIPP. This alternative also employs a facility similar to the WRPF described above to receive and characterize material retrieved Pit 9. The TRU soil fraction is hrther processed through a thermal desorption system to remove organic contaminants before it is subjected to a chemical leaching process that concentrates the TRU and produces a soil stream that is less than 100 nCi/g. The concentrated TRU is added to the waste TRU fraction that is treated by incineration to reduce the overall volume. The reduction in volume of TRU material that is shipped to WIPP in this case is about 90%. There is, however, a large increase in the volume of material that is returned to the pit. As in Alternative 1, the non-TRU material contaminated high concentrations of PCBs or uranium will be set aside until additional capability is provided as part of later projects. Non-TRU material that does not contain PCBs or uranium but is contaminated with VOCs is treated in a separate TDF and all the non-TRU material is returned to the pit. Descriptions of the process and facilities needed to support these functions are provided below.

2.3.1 Process Description

Alternative 4a is the most complicated process design of the three considered in this report but provides the most reduction in volume of the TRU waste. A block flow diagram of the process is provided in Figure 13. More detailed process flow diagrams are on drawing sheets 4A-PF-1 through 4A-PF-7 in Appendix I. The process begins in the WRPF as with the other alternatives, where soil and waste are segregated and assayed. The TRU fraction is transferred to the TRU thermal desorption system, which is much like the non-TRU TD system described in the previous sections. In the thermal desorption process, the TRU soil is heated in the TD vessel by hollow screws in which hot oil is circulated. The screws also move the soil through the vessel. The soil is heated to about 175°C, which evaporates the VOCs and, because the boiling point of water is in the same range as the boiling points of the VOC contamination, evaporates the water in the soil as well. Heavy oil fractions such as the Regal Oil remain in the soil. A small steam flow is used to sweep the VOCs and water vapor from the desorber vessel to the condenser. In the condenser, the water vapor and VOCs are condensed to liquid form and collected. As in the non-TRU system described in the previous alternatives, the condensed organics are separated from the water and the water is polished to remove any remaining trace VOC contamination. The organics are stored for processing in the TRU incinerator or, if desired, for offsite treatment. The water is stored for later treatment in the leach system evaporator.

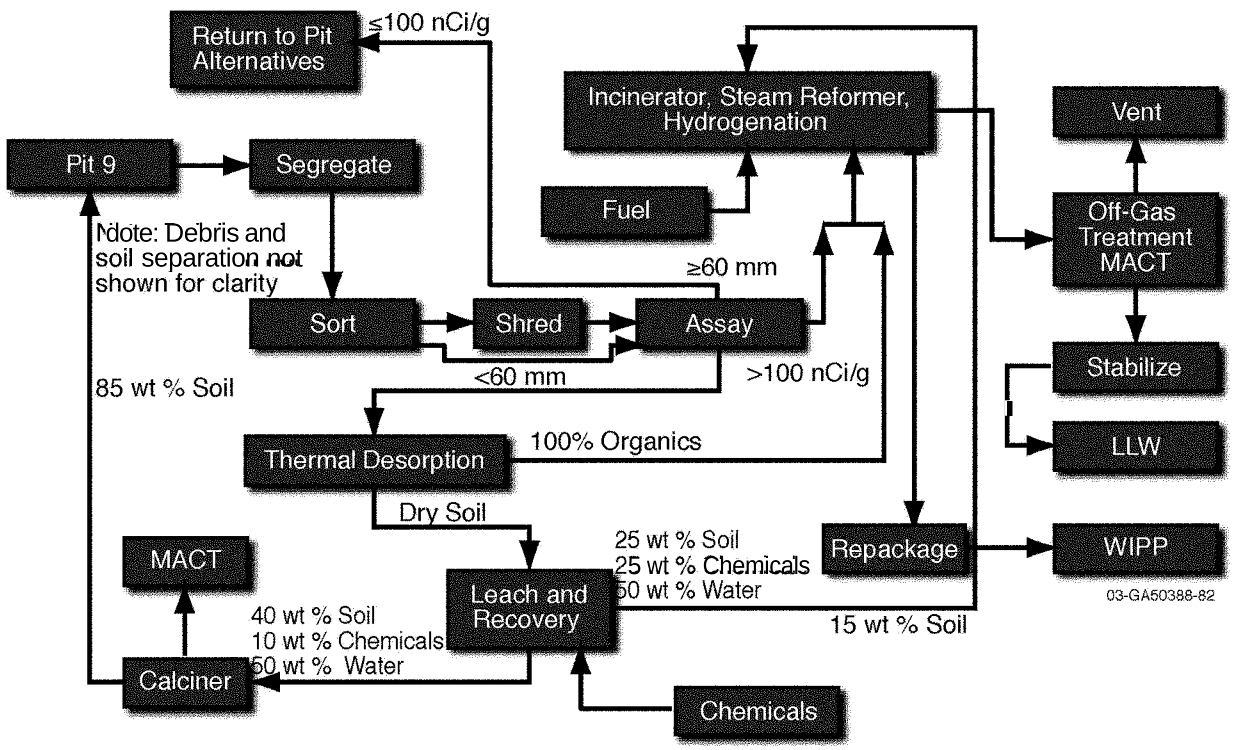

Figure 13. Alternative 4a (Thermal Desorption, Incinerate, and Leach) process flow.

The treated soil is transferred to the leach process for the next step in the process. Here, the soil is exposed to concentrated nitric acid at about 95°C for five hours. The nitric acid will dissolve the hydrated plutonium oxides and, unfortunately, the carbonates and some other compounds in the soil. The fact that as much as 30% of the soil could be dissolved by the nitric acid increases the acid consumption significantly. A counter current leach and wash technique is used to dissolve the actinides and separate the liquid and dissolved metals (including actinides) from the remaining solids. The theoretical reduction of TRU contamination, as calculated in the mass balance, is about 98%. It should be noted that this value is based strictly on the calculations and assumptions made in the mass balance and must be validated by testing. The solids are transferred, as a slurry, to the drying and calcining system. In the calcining system, the solids slurry, plus other liquid streams, are first dried and then calcined at high temperatures. The calcining process is an important step in achieving the overall volume reduction for the process. The high temperature achieved in the calciner converts essentially all of the dissolved nitrate compounds (mostly sodium nitrate) to metal oxides and gaseous oxides of nitrogen (NO_x). The solids are cooled and packaged for return to the pit. The NO_x from the calciner is passed to the high NO_x off gas treatment train, which consists of a cyclone separator to remove large particulate, a cooler, and baghouse to remove fine particulate, and a two stage reducing and oxidizing section. In the reducing section, a propane flame increases the off gas temperature to about 1,200°C and establishes a reducing atmosphere. These conditions convert the NO_x to nitrogen, carbon monoxide, and dioxide. The resulting gases are quenched to reduce their temperature and passed to the oxidizing section. In the oxidizing section, additional fuel and air complete the oxidation of the CO at reduced temperatures, while minimizing the production of any additional NO_x. The gases are again quenched and, after passing through HEPA filtration, exhausted out the facility stack.

The filtrate from the leach process is routed to a precipitation system where the dissolved actinides and some of the other dissolved metals are precipitated using oxalic acid. The leach cycle takes approximately five hours while the precipitation process takes about ten hours. Two precipitation tanks, each sized to contain 10 hours of production, are used. One is being filled while the precipitation process is occurring in the other. The precipitates are filtered and transferred to pencil tanks for storage until they are injected into the incinerator.

Waste, including the TRU sludges, is transferred to the TRU incinerator for treatment. This incineration system is very similar in concept to the one described for the non-TRU alternative but it does not have to handle the high solids load of the VOC contaminated soil. The TRU waste is fed to the primary combustion chamber, the rotary kiln. Liquids from the thermal desorption processes and the slurry containing the TRU are injected via nozzles into the primary combustion chamber. The combustion gases pass to the secondary combustion chamber where additional air and propane are added to maintain the temperature at 1,100°C. The secondary chamber has a residence time of at least 2 seconds. This temperature and time assure that any hazardous chemicals are completely destroyed. The off gas is routed to the off gas treatment train where contaminants are removed to the levels required by the MACT rules for hazardous waste combustors. The initial step in the off gas train is the cyclone separator where larger particulate is removed from the stream. Then the gases pass to the scrubber where they are cooled and additional particulate and other gaseous contaminants such as hydrogen chloride (HCl) are removed by the caustic solution in the scrubber. As in the non-TRU incinerator alternative, the scrub blowdown is evaporated and stabilized by grouting. The carryover of TRU is expected to be low enough that this stream can also be disposed of as LLW. After the scrubber, the gases pass through the HEME to remove any carry-over from the scrubber before passing through a bed of GAC to remove any trace of mercury in case it is present in the waste. After passing through two stages of HEPA filtration, the gases enter the SCR where the NO_x is destroyed. A continuous emissions monitor, as required by the MACT rules, monitors the gases before they are exhausted out the facility stack.

The VOCs are destroyed, converting them into carbon dioxide and chlorine (mostly hydrochloric acid) that is scrubbed from the off gas. The metal precipitates, including the Pu, are converted to metal oxides. Water is evaporated and passes through the system as water vapor.

In order to maintain the needed throughput and minimize cross contamination between the TRU and non-TRU streams, a separate thermal desorption system is provided for the non-TRU stream. This system is the same as that described in the previous sections. The condensed VOCs can be packaged for off-site treatment or treated in the TRU incinerator.

2.3.2 Facility Descriptions

There are three facilities associated with this alternative, the WRPF, the Waste Treatment Facility (WTF), and the non-TRU TDF. Descriptions of the facilities are provided below. Sheets 4A-A-1 through 4A-A-5 show the plans and sections of the facilities.

Architectural Description

There are two main facilities housing the treatment systems in Alternative 4a, the WRPF and the WTF, as shown. The WRPF is identical to that described for Alternative 2b.

The WTF houses the TRU treatment systems and the non-TRU thermal desorption system equipment. It is classified as an IBC high hazard H-4 occupancy due to the corrosive materials used in the chemical leach system. The WTF is constructed of structural steel and insulated metal panel. T concrete walls of the WRPF provide the fire separation between the WRPF and the WTF. The entire facility has wet pipe fire protection. The floors in the WTF are sealed concrete and will have collection sumps (not shown on the drawings) for spill and firewater collection.

The overall dimensions of the WTF are 250 ft × 150 ft. It contains the TRU and non-TRU Thermal Desorption systems, the chemical leach systems, the TRU incinerator, utility rooms, and some office and change rooms. Bins of TRU contaminated material enter the WTF TRU Thermal Desorption Storage Area from the WRPF via an airlock. This area provides a place for in-process feed storage to moderate differences in the WRPF and WTF throughputs. It is 20 ft × 62 ft ×30 ft high. Bins from the Storage Area are transferred to the Thermal Desorption Cell, which houses the thermal desorption unit itself. This cell is about 27 ft × 62 ft × 30 ft high. The vapors from the thermal desorption unit are piped to the VOC collection cell which houses the equipment for condensing the vapor effluent from the thermal desorption unit and separating the VOCs from the water. This cell is 47 ft × 32 ft × 30 ft high. Access to the GAC filters in this cell is provided from the storage area to facilitate the relatively frequent change-out of these units. TRU soil from the desorber is conveyed, via auger, to the Chemical Leach Cell. This cell houses the tanks, filter, and pumps used in the chemical leach process and is about 32 ft × 30 ft × 75 ft high. The treated soil is transferred, as a slurry, to the Calciner Cell which contains the dryer and calciner units and a glovebox type enclosure for packaging the treated soil. This cell is 30 ft × 62 ft × 75 ft high. This cell also has an access to the WRPF so that containers of treated soil can be transferred back to the assay systems and returned to the pit. A pipe and duct corridor separates the leach and calciner cells from the rest of the chemical leak system. The TRU Incinerator Cell and the Off gas Treatment Cell are located on the east side of the WTF and occupy an area that is 67 ft × 95 ft. Both these cells are 75 ft high. There is also access between the incinerator cell and the WRPF so that the ash residue can be transferred to the WRPF for assay and loading on a TRUPACT II or a HalfPACT, depending on the container weights.

A HVAC filter room, which contains the HEPA filters and ventilation exhaust fans, is located above the thermal desorption cells. The overall size of this room is 90 ft × 95 ft × 20 ft high, extending the height of the building in this area to 50 ft.

Structural

The WRPF structure nearly identical to the design discussed for Alternative 1. The WTF is expected to be a PC-2 structure and is constructed of structural steel and metal panels. The process cells are designed to provide containment of leaks or fire suppression water. The concrete floor is epoxy coated to resist chemical attack and is sloped to one side where a gutter collects any spillage. The gutter is equipped with a sump so liquid can be removed with a pump or portable wet/dry vacuum cleaner.

Mechanical

Mechanical process equipment is described below in the order it will be encountered in the process. Equipment numbers, noted on the Sheets 4A-PF-1 through 4A-PF-7, are used to identify equipment discussed in this report. Generally, the mechanical equipment was selected to minimize use of clean (new) air or water yet accomplish the treatment goals. For this reason screw conveyors (augers) were selected over other bulk material handling methods because they have fewer moving parts and they can be sealed with bolted covers with vents to the off gas treatment system at the feed and discharge ends as well as at intermediate locations. Drive shafts are sealed using a double seal with purge gas applied between the two seals. Use of screw conveyors will minimize airborne entrainment of particulate from the process stream and allow the internal volume of the auger to be maintained at a negative pressure with respect to the surrounding room. The inside of all process equipment is considered Zone III due to radioactive contamination in the Pit 9 debris. All process equipment is manufactured from stainless steel materials to aid in decontamination and decommissioning.

Bulk material transfer screw conveyors are designed to operate only 12 to 15% full to minimize contact and wear of the intermediate hanger bearings from silica sand in the Pit 9 soil. Inclined conveyors are held to less than 20º rise from horizontal and have a ½ standard pitch to aid in moving material uphill.

From a plant availability perspective, rotating equipment such as pumps that are considered crucial to the operation of the plant has installed spares (e.g., duplicate pumps, only one of which is normally operating). However, to save costs major equipment items such as evaporators, the calciner, etc. have not been duplicated.

Thermal Desorption Systems

Alternative 4a contains two thermal desorption processes similar to the non-TRU process described previously. The first TD process removes the VOCs from the TRU stream prior to sending it to the chemical leaching process. The VOCs collected from this process are incinerated; the water collected from the process is transferred to a leach tank for hrther processing. The dried product is also transferred to leaching operations. The second TD process treats non-TRU stream as described in the previous alternatives. The major equipment for both thermal desorption processes are listed below with a brief description. Equipment that is specific to one of the thermal desorption processes are so identified. All the other items are common to both processes.

Feed Hopper – Waste feed for the thermal desorption system is stored in hopper HOP-300 1 to allow feeding the TD continuously. The carbon steel hopper is sized to hold 24 hours of feed materials or approximately 20 $yards^3$ and is about 8 ft × 8 ft × 10 ft tall. Structural supporting materials suspend the hopper off the facility floor and provide the elevation required for valving and interfacing with the thermal desorber. The hopper will be coupled directly to the desorber through valves to reduce the flow of air into the TD system. A slide isolation valve V-3002 provides positive shut-off capabilities and acts as a redundant means to separate the hopper from the thermal desorber. A second valve, the double flap gate valve V-3001, controls the amount of material entering the TD by metering the volume of feed. This valve can be electrically or pneumatically actuated and is designed to withstand the higher temperatures coming from the TD. Details of this valve are in Appendix B.

Rotary Screw Auger – Auger A-3001 receives the metered waste from the feed hopper through the valves and provides it to the thermal desorber. This carbon steel rotary screw auger is 1 ft in diameter and has a throughput capacity of 1,000 kg/hr. A double housing with seals provides contamination and dust control. Augers A-3002 and A-3003 are similar.

Thermal Desorber – The thermal desorber TD-3001 consists of an insulated chamber containing two large, heated, rotating screws where the soil/debris being treated is indirectly heated to remove water and VOC's. The waste is heated by circulating hot oil at 260°C through two hollow flighted screws in a jacketed W-trough housing. The screws have 20-inch nominal diameter flights, a 20-foot working length with a 6-inch pitch mounted on 10-inch pipe shafts. The material of construction is carbon steel. Shaft seals are designed to prevent loss of material or gases from or the flow of gases into the system. Resonance time for the debris is controlled by the speed of the screws and is adjustable such that the debris reaches the desired temperature while in the desorber. The TD unit is operated at negative pressure to eliminate fugitive emissions. Steam is used as sweep gas to move the vaporized organics to the condenser. A propane fired boiler B-3001 supplies superheated steam to the TD at approximately 39 kg per hour. Details of the TD unit are in Appendix B. A hot oil reservoir R-3001, pump P-3008, and heat exchanger HX-3001 circulate and maintain proper temperature of the oil for the TD unit. From the desorber the process stream splits. The dry desorbed material will go to the leach step of the process and the VOCs, steam and other gases will go to the condenser.

Cooling Screw (≤ 100 nCi/g) – The cooling screw auger CS-3002 has an 18-in. diameter hollow flighted screw housed within a 20 ft jacketed U-trough chamber. The screw flights have a 6-in. pitch and are welded onto an 8-in. pipe shaft. The screw receives facility water at 75°F and indirectly cools the thermal desorbed waste from 300 to 100°F. This screw is fabricated from stainless steel and designed for a pressure of 100 psig. A 5 HP drive motor and inline speed reducer rotate the screw. The cooling medium for this unit is processed water that is recycled through the facility-cooling tower. Details of the cooling screw auger are in Appendix B.

Out-feed Hopper – The cooled soil/debris exiting the cooling screw is transported by auger A-3002 to the out-feed hopper HOP-3002. This hopper is similar in design to the feed hopper but sized for 15 hours of storage capacity and is approximately 6 ft × 6 ft × 10 ft tall.

Repackaging Station Glovebox (≤ 100 nCi/g) – From hopper HOP-3002 the soil/debris is transported by auger A-3003 to the repackaging station glovebox GB-3100. This stainless steel glovebox is approximately 15 ft long, 8 ft wide, and 8 ft tall and is structurally supported some 6 ft above the facility floor. A bag interface port adapted for the 5 ft × 5 ft × 6 ft boxes is used to provide primary containment while boxes are being filled. The glovebox design incorporates gloveports, ventilation, and lighting. A box positioning system under the glovebox allows operators to reposition the box while filling. This positioning system consists of a cart on tracks that can be easily moved in the X, Y, and Z directions.

Condenser – The condenser C-3001 is a shell and tube model that that is sized to handle the vapor streams generated by the thermal desorber. This unit condenses the vapor stream on the tube side, giving more positive control of the possibly radioactive stream. This unit allows condensate to be piped into a tank, instead of draining off the outside of the tubes into a catch tank, giving more positive control of the condensate. The vent condenser will operate at the required negative pressure. Design vapor inlet temperature will be 345°F, while condensate temperature will be 120°F. The design throughput for the condenser is 680 lbs of condensate per hour, assuming 93% water and 7% organics. This rate will allow sufficient additional condensing capacity to account for unforeseen moisture in the waste. The shell of this condenser is approximately 3 ft in diameter and 6 ft tall. The cooling medium for this condenser is processed water that is recycled through the facility-cooling tower. The condensate off gas coming off the condenser is passed through a GAC bed GAC-3010 and then filtered through HEPA-3020 prior to monitoring and discharging up the facility stack.

Condensate Pump - The condensate pumps P-3003 are ¼ HP each and are designed to pump down the liquids accumulating in the condenser. Each pump is sized at 6 gpm. High and low level controls in the collection tank will control the condensate pump to maintain sufficient level in the tank to prevent pump cavitation.

Organic Separator Tank - The organic separation unit is a settling tank that provides sufficient residence time to allow the halogenated hydrocarbons to coalesce and settle. A 600-gallon tank will provide an 8-hour residence time. The separation and settling is enhanced with Teflon baffles that provide a surface for the coalescing to take place. A sight glass will allow the operator to drain the organic phase from the tank. High and low tank level switches will control water pumps P-3005 to pump the water from the separator tank for hrther processing.

VOC Storage Tank – The organic phase coming from the separator tank is pumped with pumps P-3004 to the VOC storage tank T-3002. This tank has a capacity of 70 gallons, which is equal to about three days worth of organic liquid accumulation assuming the organics are spread evenly through the waste stream. Pump P-3006 transfers the organic liquids from the VOC storage tank to drums and the drums are sent off site for treatment.

Bonifibers and GAC Beds – Water coming from the organic separator tank is pumped through Bonifibers and carbon beds to an evaporator. The pump (P-3005) is sized greater than 2 gpm to increase the efficacy of the carbon bed. Low flows in the carbon beds are inclined to produce channeling, reducing the life of the beds before breakthrough. A 55-gallon drum of Bonifibers is used as an initial sorption step to separate the organics from the water. Bonifibers adsorb 25 times their weight in organics, normally oil. Traces of oil and similar organic compounds are removed in this step. A drum of Bonifibers will last about a week. The low flow of water at this point in the process allows the use of 55-gallon drummed carbon beds. Using four drums in series will allow the first drum to be hlly saturated before it is changed out. The drums are refillable to reduce costs. The depleted carbon can be sent through an incinerator for disposal. The residual clean water stream exiting the carbon bed is flowed to a collection tank, T-3003.

The TD discharges hot, 300°F soil into an inclined transfer auger (A-4010). Auger A-4010 is 8 inches in diameter with a 4-inch pitch. It is 25 feet long, inclined at 20" from horizontal. It is manufactured from 304 stainless steel materials and operates at a speed of 25 rpm to minimize air borne particulate. The conveyor is driven by a 2 hp electric motor through a belt drive and shaft mounted gear reducer. The conveyor has two intermediate hard iron bearings and is hrnished with double shaft seals at each end with a nitrogen purge. At the discharge end the conveyor has 6 in. of reverse flight screw to push material away from the shaft seal and into the discharge opening. The conveyor is a deep U-trough design with room above the screw to keep vent gas velocities low and minimize entrainment of dust particles.

A vibrating screen (S-4010) receives the hot soil from the auger A-4010. The screen operates inside a dust enclosure on top of bin B-4010. The screen deck is 3 ft wide × 4 ft long woven wire deck to separate all material less than 1/4 in. from the balance of the soil. The oversized material that does not pass through the screen is discharged into a short transfer auger (A-4011) and then into a bulk transfer container. Material less than or equal to ¼ inches in size is dropped directly into the surge bin. The oversized fraction of the total flow is not known and will vary with the pit areas being excavated. The conveyor handling the material greater than 1/4 in. is sized to handle 100% of the flow although this will probably not be the case.

Several screen types were reviewed for the hot contaminated soil screening. Vibrating screens with a drive motor external to the screen and hot material areas is the preferred method. Other screen types such as a trommel screen could also be used. A trommel is simple in design and can be supported from its drive shaft to eliminate exposure of mechanical parts to the hot soil. A trommel screen is not as efficient as a vibrating screen so more screen surface would be needed to screen the same amount of material.

Screens selected for this application should include a method of self-cleaning. The material will be hot and dry so it will not likely blind the screens. However, due to the location of the screen, access will be difficult and production would need to be suspended to perform work on the screen.

The surge bin, B-4010, located under the screen is sized to hold about 10 hours of production or about 7,200 kg. The bin is insulated to reduce heat loss to the room and as a safety precaution against burns. Soil from the bin is fed to the leach tanks for extraction of the actinides. The leach process is a batch process and the TD runs continuously; therefore, the surge bin is necessary to receive the soil from the TD between batches sent to the leach tanks. The leach cycle time is five hours, so approximately 3,600 kg of soil is sent to leach in a period of 20 to 30 minutes every time a new batch is started. The bin is operated under a vacuum of -2 to -3 in. of water to eliminate dust leakage. The bottom of the bin is cone-shaped to facilitate discharge of the material and is also equipped with a vibrating bin discharge device. The discharge device is necessary because the bin can become plugged with material compacted by a combination of the screen vibration and intermittent (batch) flow. A star valve controls the volume soil discharged from the bin and provides a barrier to moisture from the leach process.

Three transfer conveyors, A-4110, are located downstream from the surge bin to transfer the contaminated soil to the leach process, as shown on Sheet 4A-A-2. These auger conveyors are operated every five hours to load a new batch of soil into the first leach tank. All three conveyors have a 14-in. diameter with a 7-in. pitch and operate at 38 rpm. The longest conveyor is 67 ft long and is inclined 20° from horizontal to raise the soil to the inlet of the first leach tank. The other two conveyors are 8 ft and 11.5 ft long and are also inclined. All conveyors are insulated to reduce heat loss to the room and to provide safety protection against burns. The conveyors are hrnished with deep U-troughs, seals, and bolted covers and are maintained at a vacuum of -3 in. of water through the off gas system. Doubled shaft seals with a purge are provided at the head and tail ends of the conveyors. All three conveyors are driven at the head end with a shaft mounted gear reducer, V-belt drive, and electric motor. Variable speed drives are not necessary because the augers inherently accommodate moderate changes in flow rates through changes in material levels in the U-troughs. The conveyors are made of type 304 stainless steel. Self-aligning bearings with housings are located at the head and tail ends of each conveyor. The head end bearing is fixed and the tail end bearing is floating to allow for normal thermal expansion. For the 67 ft conveyor, the thermal expansion could be as high as 1.2 in. when handling soil at 300°F. This expansion is accounted for internally by slotting the holes in the shaft coupling at each hanger bearing.

A 10-in. knife-gate valve, V-4110 is located between the last transfer auger and the first leach tank, T-4110. This valve isolates the moist tank environment from the transfer augers after completing each batch transfer. The transfer augers will contain some residual material in the bottom of the U-trough after each batch transfer operation and will tend to cool down between each batch every five hours. This residual material will set up if moisture is allowed to condense in the augers.

Chemical Leach System

Leach Tanks – The leach tanks receive the contaminated soil after removal of VOCs and oversized material. There are three leach tanks in the process in which the actinides are leached from the soil with nitric acid. The operation can best be viewed by looking at Figure 14 and understanding that the nitric acid solution moves through the three tanks and filter F-4100, in a reverse direction from the soil (solids).

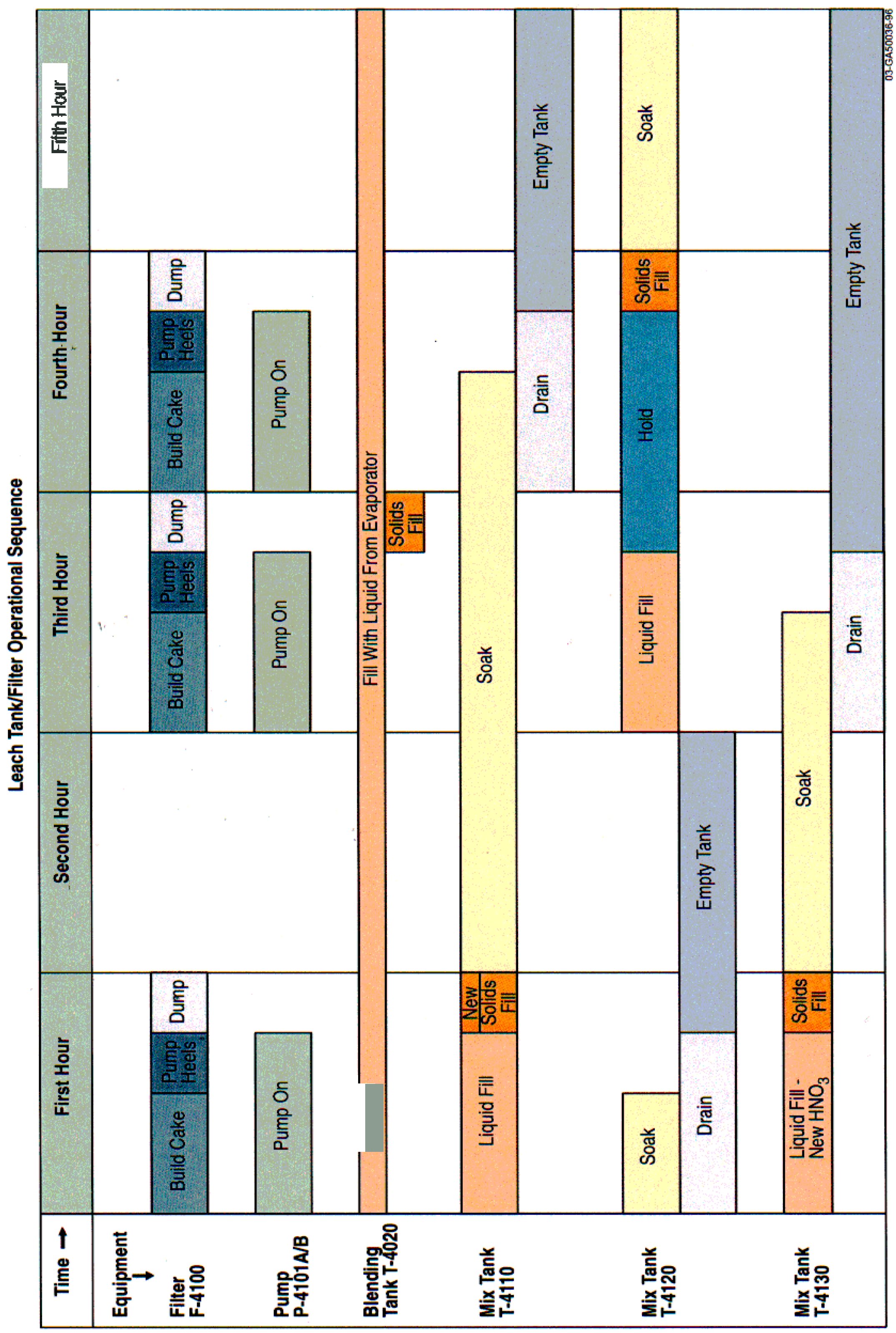

Figure 14. Leach tank/filter operational sequence.

Mix tank T-4110 receives the soil first. It is mixed with nitric acid solution that has been pumped through the filter from tank T-4120. After soaking for 2.5 hours the soil and acid slurry in tank T-4110 is pumped through the filter, F-4100, where the solids are separated from the liquid. The liquid goes on to the precipitation system and the solids are dumped from the filter to tank T-4120. In a similar fashion, the soil in tank T-4120 is mixed with filtered acid from tank T-4103 and allowed to soak for a period of 1.5 hours. Likewise, after soaking the soil/acid mixture in tank T-4120 it is pumped through the filter and the soil is sent to tank T-4130 and the liquid is sent to tank T-4110. In T-4130, the soil is mixed with fresh nitric acid and allowed to soak for 1.5 hours. When soaking is finished in tank T-4130, the soil/acid mixture is pumped to the filter. Following filtration, the soil is sent to the calciner feed blending tank, T-4020, and the liquid is sent to tank T-4120.

The three leach tanks and blending tank are 8 ft in diameter and approximately 9 ft high. They have an internal volume of 3,100 gallons and are fabricated with a cone-shaped bottom and top to hlly enclose the contents of the tanks. A vacuum of –3 in. of water. is maintained at all times inside the tanks. Each tank is equipped with a cantilevered mixer that extends through a 24-in. flanged nozzle that also supports the mixer and provides a means of entry into the mix tank. The mixer has a shaft seal to separate the tank contents from the room environment. The mixers are operated continuously to ensure that the soil/acid slurry does not settle. The three leach tanks also include a steam jacket on the vertical sides and tank bottom to maintain a process liquid temperature of 95°C.

A process filter, F-4100, is located above the three leach tanks and blending tank. This filter is a FundabacB filter that is relatively new to the nuclear industry. A description of the filter can be found in Appendix E. The filter for the leach process is 6 ft in diameter, 17 ft long and contains 69 filter candles. Each candle is 98 in. long. With a filter cake thickness of 1.5 in., the unit will hold approximately 2.3 m^3 of filter cake. The filter housing is manufactured of type 316L stainless steel and is designed for an internal pressure of 150 psi and full vacuum. Each batch of soil will pass through the filter three times as it is processed through the leach system.

Two valves are located below the filter, a knife gate valve, and a three-way diverter valve to deliver the solids to the appropriate leach tank or calciner feed blending tank.

Two pumps, P-4110A and P-4110B are located below the leach tanks to pump slurry from the leach tanks to the filter, F-4100. The pumps are piston pumps with the same design as concrete pumps but fabricated out of stainless steel to handle the acidic leach solution. See Appendix E for additional information on the slurry pumps.

After the soil is processed through the leach tanks it is delivered to the calciner blending tank (T-4020) where it is combined with the filtrate from the precipitation system forming a slurry containing about 20% solids. This slurry is then pumped from the blending tank and sprayed into the dryer section of the calciner system. A backup surge tank, T-4021 is provided to receive soil from the leach system and liquid from the evaporator in the event the calciner must be shutdown. The surge tank has a working volume of 7,200 gallons, which will provide about 12 hours to correct any problems before the entire leach process must be shut-down. Both the blending tank and the surge tank are equipped with mixers to keep the slurry in suspension and both are maintained under a vacuum of –3 inches of water through the off gas treatment system. Both tanks are also equipped with diaphragm pumps to deliver the slurry to the dryer spray nozzles.

Slurry Dryer - The dryer is a jacketed quad-screw custom designed machine with hollow flights, C-4100. Hot oil at 450°F to 500°F, is circulated through the hollow flights to indirectly heat the soil to 300°F and evaporate the water. Additional details concerning the dryer can be found in Appendix E. The dryer does not have the ability to dry the 20% solids slurry from the blending tank without a substantial amount of dry material to mix with the slurry. Therefore, most of the dried soil is returned to the feed end of the dryer through a series of three screw conveyors. The first of these three screw conveyors, A-4105 receives the dried soil at the discharge end of the dryer. This screw, A-4105 has two outlets. An intermediate outlet diverts some of the dried soil into the high temperature calciner and an outlet at the drive end drops the remaining soil into the tail end of an inclined auger, A-4102. This inclined auger moves the soil up to a third auger, A-4106, where it is returned to the inlet end of the dryer, C-4100. Approximately 70% of the dry soil will be recycled back to the drier inlet where it will mix with the incoming slurry producing a mix of 40% liquid and 60% solids.

High Temperature Calciner and Cooling Auger – The dry soil that is discharged from the intermediate spout on auger A-4105 drops into a star valve, V-4130, which controls the feed rate to the high temperature calciner, C-4103. The high temperature calciner is an electrically heated twin screw that heats the soil from 300°F to 1,300°F. Additional details concerning the calciner can be found in Appendix E. Hot soil from the calciner is discharged into a surge bin, B-4101. The capacity of the surge bin is 4,500 lbs, which is just over two hours of production. In addition, the surge bin provides a free fall discharge from the calciner to minimize any unnecessary loads on the calciner and it provides a visual indication of material conditions and equipment operation. The surge bin gravity feeds material into the cooling auger, C-410l, where the soil is cooled to 130°F. A detailed description of the C-4101 is available in Appendix E. The cooling auger is a 24-in. diameter hollow flight single-screw inside a jacketed U-trough shell. Chilled water is circulated through the hollow flights and jacket to cool the soil indirectly.

Following the cooling auger are two 8-in. diameter transfer augers, A-4107 and A-4108, which convey the soil to a packaging station where the soil will be loaded into containers for transfer back to the pit.

All the augers in the calciner room are insulated to limit heat loss to the room and to protect operators from burns due to incidental contact with hot equipment. In addition all the transfer augers, surge bins and screw type process equipment is sealed with bolted covers and vented to the high-NOx off gas treatment system.

A few other types of calciners were considered for this application. These included direct and indirect fired kilns. A negative feature of the rotary kiln is the seals separating the internal side of the kiln from the room environment. These seals, which would probably be labyrinth seals, in combination with a high temperature fabric must be able to seal the kiln during normal rotation as well as deal with the change in length and diameter due to heat up from ambient temperature. Experience shows that this area is very difficult to seal and loss of confinement is a real concern. Even though the soil has been treated the residual contamination levels require positive confinement. The direct-fired kiln also has the disadvantage of adding a large volume of air along with combustion gases and additional NOx to the process flow that must be treated in the off gas system. The direct-fired kiln does have the advantage of being able to handle a slurry feed without recycling dry material. A wet process cement kiln for portland cement is a good example of this capability. The indirect fired kiln does not add combustion gasses to the process but it is thermally inefficient so it must be large with respect to other equipment to accomplish the same processing goals. In addition, the indirect fired kiln will not handle slurry feed due to a caking problem at the inlet and the inner shell must be operated at higher temperatures because most of the heat transfer is radiant. Fluidized bed calcination was considered but ruled out due to the high volume of air and combustion gas that would be added to the off gas treatment load. A tray type or multiple hearth type dryer/calciner and a double cone dryer were also considered but not reviewed in detail since they did not appear to offer any obvious advantages over the equipment that was considered.

Off gas Treatment System – The high-NOx off gas treatment system is designed to remove the nitrogen oxides that were released in the calciner. This system is located in the same room as the incinerator off gas treatment. The high-NOx treatment equipment includes a hot cyclone and baghouse located near the calciner. Particulate removed by these two devices is returned to the dry soil flow stream and continues with soil to the pit. The filtered gas from the baghouse is ducted to NOx reduction equipment, Noxidizer® (see Appendix E). This is followed by a two-stage HEPA filter, HEPA-6020, an induced draft blower then it is exhausted to the stack.

Actinide Precipitation – After working its way through the leach process, the 8 molar nitric acid solution with any dissolved materials is sent to the precipitation tanks, T-4600A and T-4600B. These two tanks are used alternately to neutralize the acid and precipitate the actinides using oxalic acid. The precipitation tanks are 8 ft in diameter, 13.5 ft high and have a working volume of 4,000 gallons. The tanks are fabricated with a cooling jacket to remove heat from the tank during the exothermic reaction. They are also hrnished with mixers to keep the tank contents in suspension and to improve the heat transfer to the cooling jacket. The tanks are fabricated of type 316 stainless steel and designed to Section VIII, Division 1 of the ASME Boiler and Pressure vessel code for an internal pressure of 15 psig and full vacuum. During operation, the tanks will be vented to the off gas system that maintains a vacuum of -3 inches of water in the head space of the tank.

A process filter, F-4500, is located above the two precipitation tanks. This filter is a FundabacB type of filter that is relatively new to the nuclear industry. A description of the filter can be found in Appendix E. The filter for the precipitation process is 5 ft in diameter, 15 ft long and contains 48 filter candles. Each candle is 98 in. long. The unit holds approximately 1.0 m^3 of filter cake with a filter cake thickness of -in. The filter housing is manufactured of type 316L stainless steel and is designed for an internal pressure of 150 psi and full vacuum. The contents of each precipitate tank pass through the filter once as it is processed through the system. The clear liquid from the filter goes to surge tank, T-4640, and the filtrate comprised of calcium oxalate, miscellaneous solids, actinides, and up to 50 w% liquid is gravity fed to one of six pencil tanks, T-6010A through T-6010F.

There are two operational uncertainties concerning this filter.

- The precipitate particle size distribution is unknown. The FundabacB filter will treat particle sizes from 200μm down to 0.5μm without filter aids and solid concentrations between a few ppm to 15% solids. Filter aid is not identified in the PFD and has not been included in the facility cost as far as what equipment will be needed to receive, store and handle the filter aid.
- The question of nuclear criticality in the filter has not been addressed. The filter will concentrate the actinide contaminated precipitate in the filter cake while the filter is filled with water. If there is a criticality problem, then smaller multiple filters or a limitation on cake thickness may be necessary to resolve the issue, but it will result in a more complicated and costly system than what is currently under consideration.

The surge tank, T-4640, receives liquid from the precipitate filter. The tank is primarily a surge tank with a working volume of 6,000 gallons. The tank is also equipped with a cooling coil to remove exothermic heat that is produced when the 0.5 M nitric acid solution is neutralized with 50% caustic solution. The surge tank head space is maintained at a vacuum of -3 in. of water through the off gas system.

A centrifugal pump, P-4640, transfers the liquid from the surge tank, T-4640, to the evaporator, T-4700, based upon liquid level in the evaporator. The evaporator is comprised of two basic parts, a re-boiler and a flash column. This type of evaporator works on the thermal siphon created when the liquid is heated in the re-boiler and rises and boils then flows to the flash column. In the flash column, the saturated steam and water with dissolved salts are separated. The steam is drawn off to the off gas treatment system and the liquid is collected in the bottom of the flash column. Liquid from the bottom of the flash column flows back to the evaporator where it is mixed with cooler incoming liquid, then re-heated in the evaporator where the process is repeated. The nitrate salt solution that is produced is at its greatest concentration in the bottom of the flash column. At this point a stream of liquid is drawn off and sent to the calciner blending tank, T-4020, where it is mixed with the soil from the leach process. The evaporator process must be carefully monitored to ensure that the nitrate salt solution does not become so concentrated that salt deposits form on the evaporator tube walls. Two similar thermal siphon evaporators are currently in operation at INTEC, in the high level liquid waste (HLW) system and in the process equipment waste system. The evaporator and flash column shells are fabricated with type 316L stainless steel and the tubes are nitronic 50 to minimize corrosion due to the salt solution. Both the evaporator and flash column are maintained at a vacuum of -3 inches of water through the off gas system and both vessels are insulated to minimize heat loss to the room and to protect operators from inadvertent contact with the hot exterior shell surfaces.

The evaporator, flash column, precipitator tanks, filter, oxalic acid feed tank and the caustic feed tank are all located in one room with spill containment. The oxalic and caustic tanks are in the same room but have individual spill containment for each tank and are separated from the other tanks with a cofferdam. The surge tank room located adjacent to south of the precipitator room is also hrnished with a spill containment. A step-over curb is provided at the entry. The floor is sloped to one side where a gutter collects any spillage. The gutter is equipped with a sump so liquid can be removed with a pump or portable wet/dry vacuum cleaner.

The leach and precipitation parts of the treatment require the use of three chemical compounds. In the leach process an **8** molar nitric acid is used to dissolve the actinides in the soil. In the precipitation process, 50% caustic solution is used to neutralize the nitric acid and oxalic acid is used to precipitate the actinides. These three chemicals are used in large quantities so they are delivered to the facility in bulk. The nitric acid is delivered as 13 molar liquid, the caustic is delivered as a dry pellet, and oxalic acid is delivered in pellet form. A separate chemical receiving and storage building outside the facility fence is shown on the facility site plan (Sheet 4A-C-2 in Appendix I). The chemicals do not have radioactive contamination when they are received so it is appropriate to receive and store the chemicals at a facility that is less costly than a potentially contaminated structure located inside the fence. The chemical storage building is 60 feet × 70 feet and is equipped with a drive through truck bay where chemicals can be offloaded out of the weather. The truck bay is equipped with spill control for bulk liquid and floor space to receive and store the dry chemical. The building floor plan can be found in Appendix I, sheet 4A-A-5. Four tanks inside the building store the chemicals for use in the process. Two tanks, labeled T-4410 A and T-4410B, can store up to 36,000 gallons of 13 molar nitric acid (1 week supply). Another tank, T-4650, is a 12,000-gallon combination mix and storage tank for 1.4 molar oxalic acid. The fourth tank, T-4610, is a 3,000-gallon combination mix and storage tank for 50 **wt%** caustic solution. The caustic tank is hrnished with a cooling jacket to remove excess heat from the mixing process. The caustic and oxalic acid are both delivered in bulk sacks and can be mixed with water as needed. A forklift is available at the chemical storage building to offload delivery trucks and to move the bulk sacks from dry storage to the automated feeders at each mix tank. A spill control curbing is provided in the building around the tanks to contain any leakage. For obvious reasons a curb also separates the caustic storage tank spill containment area from the acid tanks spill containment area.

Liquid from the storage facility is pumped to the treatment facility via double contained piping to chemical feed tanks located inside the treatment facility. The feed tanks are equipped with visual level indication, level transmitter and a metering pump to feed a controlled amount of chemical into the leach system or precipitator system as required by the process.

Incineration Systems

The TRU waste material (TRU material not treated in the leach system) is treated in an incinerator. This material includes shredded debris and products from the thermal desorption and leach systems. It provides volume reduction of solids and evaporates and decomposes the products from the thermal desorption and leach systems. The major components include the rotary kiln and off gas treatment systems described below.

Rotary Kiln Incinerator – The propane fired incinerator is an Anderson 2000 Model 5.3–7.5 rotary kiln which has a 64-in. inside diameter shell surrounded by a 9-in. thick refractory lining and is 32 ft from end to end. The shell is fabricated from ¾-in. carbon steel and is temperature maintained above 175°C during operation. The kiln capacity is 5.0 to 20 tons of waste per 24 hours. The soil and debris that are slated for incineration are transported in ICBs to the incineration cell. The ICBs are positioned over the in-feed hopper and the contents are discharged into the receiving hopper. From the hopper, soil/debris is metered into the incinerator at a controlled rate to achieve a minimum of 99.99% destruction of hazardous components and 99.9999% for PCB wastes. The kiln is designed to operate at 0.2 to 2.7 rpm with a maximum heat release inside the kiln of 7.5 MMBtu/hr. A 30 hp drive motor rotates the incinerator through a triple reduction gear drive. The system is sized for at least 330 days per year and 24 hour per day operation. For a more complete description of the incinerator system, see Appendix B.

Ash at 1,650ºF leaves the incinerator and is gravity feed through a cooler in preparation for packaging. The cooling operation drops the ash temperature to 105°F.The gravity cooler is a heat exchanger that utilizes cool water circulated through a series of tubes with the ash gravity fed past the exterior of the cooling tubes. The ash is then transported by auger to the repackaging station glovebox where it is packaged into 5 ft × 5 ft × 6 ft hard boxes. The repackaging glovebox uses a contact handled bagging system to contain contamination while filling the hard boxes.

The off gas from the rotary incinerator is drawn through a propane fired secondary combustion chamber or afterburner. In this chamber, the 1,650ºF off gas is hrther heated to 2,010ºF. The afterburner is a vertical cylindrical chamber that is 64-in. inside diameter inside a refractory thickness of 9 in. with a ¼-in. thick steel shell. The effective length of the chamber is 21 ft. The gas stream exits this secondary chamber and enters a hot cyclone separator where dust less than 50 microns is removed and returned to the primary combustion.

Off gas from the dust removal system will be cooled, quenched, and cleaned in an ejector venturi scrubber system. The **EVS** will scrub off gas with a high-volume recirculating caustic solution. Heat will be rejected from the **EVS** by indirect heat exchange between the recirculating scrub solution and facility cooling water. Scrubber operating temperature will be controlled to achieve a neutral liquid balance in the **EVS** sump.

Scrub solution will be maintained at elevated pH to facilitate removal of acid gasses. Caustic will be supplied as NaOH solution. Scrubber blowdown will be regulated to maintain a maximum NaCl concentration of 25% in the scrubber solution.

Scrubbed off gas will pass through the HEME to remove entrained moisture and particulate. The off gas will then be re-heated a few degrees to prevent downstream condensation during mercury vapor sorption (in a GAC bed) followed by redundant HEPA filtration.

Selective Catalytice Reduction System - A Selective Catalytic Reduction (SCR) system will be installed at the outlet of the HEPA filters to reduce NOx emissions from about 500 ppm to below 50 ppm, for a destruction removal efficiency of about 90%. Ammonia will be used as the reductant and propane will be used to supply heat to the system. Following are the individual equipment items required, which typically would be supplied as a system by a single vendor.

Off gas Preheater – A recuperative heat exchanger will use exhaust heat from the SCR to preheat the inlet off gas. The preheater should heat the off gas from the HEPA outlet temperature of 230°F to about 390°F.

Propane Burner – A 5 MMBtu/h propane burner will be used to heat 2200 Nm^3/h (3600 actual m^3/h) of off gas exiting the preheater from about 390°F to the SCR reactor temperature of 480°F to 750°F depending upon the catalyst selected.

Ammonia Injection – Ammonia will be injected into the reactor inlet duct at an NH_3/NOx ratio of about 0.90 to 0.

SCR Reactor – A refractory-lined reactor containing a vanadium-based catalyst forms the heart of the SCR system. A residence time of two to three seconds will be required. Assuming a 1 ft/s superficial velocity, the area of the reactor would be about 1 m^2 and the reactor length would be about 1 m. Ammonia slip should be less than 10 ppm.

The approximate size of such a system, including the preheater, is about 25 ft long, 7 ft wide, and 7 ft high. Approximate sizes of each section are:

Preheater – 10 ft x 5 ft x 5 ft

Burner/Ammonia Injection – 2 ft x 7 ft x 7 ft

Reactor – 3 ft x 7 ft x 7 ft

Exhaust Section – 9 ft x 7 ft x 7 ft

HVAC and Utilities

In addition to the off gas system the leach process building is required to have two ventilation confinement zones per DOE-ID Architectural and Engineering Standards. This section describes the two confinement zones, and the non-confinement area. A ventilation confinement system will be provided, which, in conjunction with the physical barriers, maintains a continuous airflow pattern from areas of low potential contamination to areas of higher potential contamination. The objectives of the confinement systems are to prevent the spread of radioactive and other hazardous materials to occupied areas and to minimize the release of radioactive and other hazardous materials in facility effluents.

The primary containment (Zone 111) is the processing equipment, which is sealed and connected to the off gas treatment system. The off gas treatment system is independent of the building ventilation and contamination control system. The off gas treatment system has at least two stages of HEPA filtration and it controls EPA regulated gases and other hazardous materials. The primary confinement boundary will include process equipment structural shells, gasketed covers, connected piping, valves and pumps, stainless steel ductwork, and gas treatment equipment. It is designed to maintain its structural integrity during and after operational and natural-phenomena design basis accidents. The secondary confinement boundary (Zone 11) consists of the process areas, which will be exhausted through two stages of HEPA filters with a single stage HEPA filter at the air inlet to these areas. The secondary confinement boundary will comprise process area walls, floor and ceiling, stainless steel ductwork, and HVAC equipment designed to maintain its structural integrity during and after operational and natural-phenomena design basis accidents.

The Zone I confinement boundary consists of the corridor areas, the building HVAC rooms and other accessible areas adjacent to the Zone III and II areas. Supply air to Zone I areas is filtered through roughing filters to minimize outside dust infiltration. During winter operations the roughing filters are removed to prevent frost buildup and the air is tempered so freezing conditions do not exist inside the building. Air supply to Zones II and III is drawn from the Zone I areas through HEPA filters, thus exhaust from Zone I will be HEPA filtered.

The non-confinement (clean area) boundary consists of offices, control room, change room, and support areas outside the zoned areas. The non-confinement areas do not require unique ventilation systems and are maintained at a slight positive pressure with respect to ambient.

Drawing sheet 4A-HV-1 in Appendix I shows the HVAC flows to all the process areas and sheet 4A-A-3 shows the location of the HVAC equipment, HEPA filters and fans.

The facility is provided with an independent chilled water system consisting of central chillers and pumps delivering chilled water to various cooling coils. The chilled water system is shown on sheet 4-HV-2. Most of the process equipment operates above normal room temperatures so a considerable amount of heat is lost from the process equipment to the ventilation system. In the incinerator area, the off gas treatment room and the leach tank room the airflows are set at 10 air changes per hour for the purpose of removing heat from equipment.

Electric resistance heating coils provide the building heat. The low capital cost of the coils and the 2-year operation of the facility do not appear to warrant the use of more efficient systems such as steam coils, direct fired gas heaters or heat recovery equipment. Use of electric coils should be re-evaluated after the process is better defined and if the expected the life of the facility changes.

Redundancy ensures proper ventilation confinement during HEPA filter change out or fan maintenance. Exhaust ductwork is located in areas that are not normally occupied. HEPA filter housings include the capability for leak testing the HEPA filters and for testing filter efficiency in place. Single stage HEPA filters are provided at all air inlets to Zone II and Zone III areas to prevent possible contamination during a momentary back flow situation when pressure differences are inadvertently lost. Confinement boundaries are also sealed to maintain isolation of contaminated areas.

Confinement zones are supplied by once-through ventilation. All airflow from these zones is HEPA filtered and discharged to the exhaust stack with no air re-circulation. The supply and exhaust fans for the Zone II and Zone III areas are powered from the standby power grid so ventilation confinement is maintained during loss of facility power. With a minimum outdoor air temperature of -45°F in the winter, the facility will need an estimated 2.9 megawatts of electrical heat to prevent freezing and maintain a room temperature of 50°F with no equipment operating. Overall, the treatment facility ventilation air is 2.8 cfm/ft^2. This is higher than the typical airflow of 1 cfm/ft^2 for process facilities, but it is necessary due to the quantity of thermal equipment operating in the facility. For most of the process areas, six air changes per hour are needed to keep the room temperatures below 80°F. In the three hottest rooms, 10 air changes are necessary in addition to custom hoods to draw the hottest air out of the room. For summer operation the estimated cooling load is 300 tons. Considerable savings in heating and cooling loads could be realized if airflows were reduced when process equipment was not operating. There are no energy conservation measures taken at this time due to the relatively short (2-year) operation of the facility.

Office space, control room, and other areas, which support the operation but are not in a contamination confinement area, are air conditioned and heated in a conventional manner. Fresh air quantities are consistent with the Indoor Air Quality standard ANSI/ASHRAE A62 that requires 20 cfm of fresh air per person.

Electrical

Power for the Treatment Facility will be provided via the existing INEEL 138kV Substation 9 located north of the proposed Treatment Facility. The description and requirements stated in the Electrical section of Alternative 1 (see page 22) are applicable to this alternative with the change being the electrical load requirements. The electrical requirements for the Alternative 4a (thermal desorption, chemical leach, and incineration of the TRU waste) and 3aP (thermal desorption of the non-TRU waste) facility were analyzed and the demand determined to be 7201 kVA. The results of the analysis are shown in the Table 4. In addition to these loads, the demand of the Retrieval Facility is added to the result to obtain the overall demand that will be connected to the existing equipment in Substation 9.

Table 4. Treatment facility 4a-3aP demand load table.

Load Type	Normal Demand KVA	Power Factor	Stand-by KVA	Stand-by Power Factor
General Loads	206	80%		
Heat	4095	100%		
Ventilation	116	80%	954	80%
Lights	327	80%	63	80%
Office Equipment	75	80%		
Process Equipment	1547	80%	202	80%
Total	6066	97.5%	1219	80%
Facility Total	7201			95.7%